ENGINEERING

An Illustrated Weekly Journal

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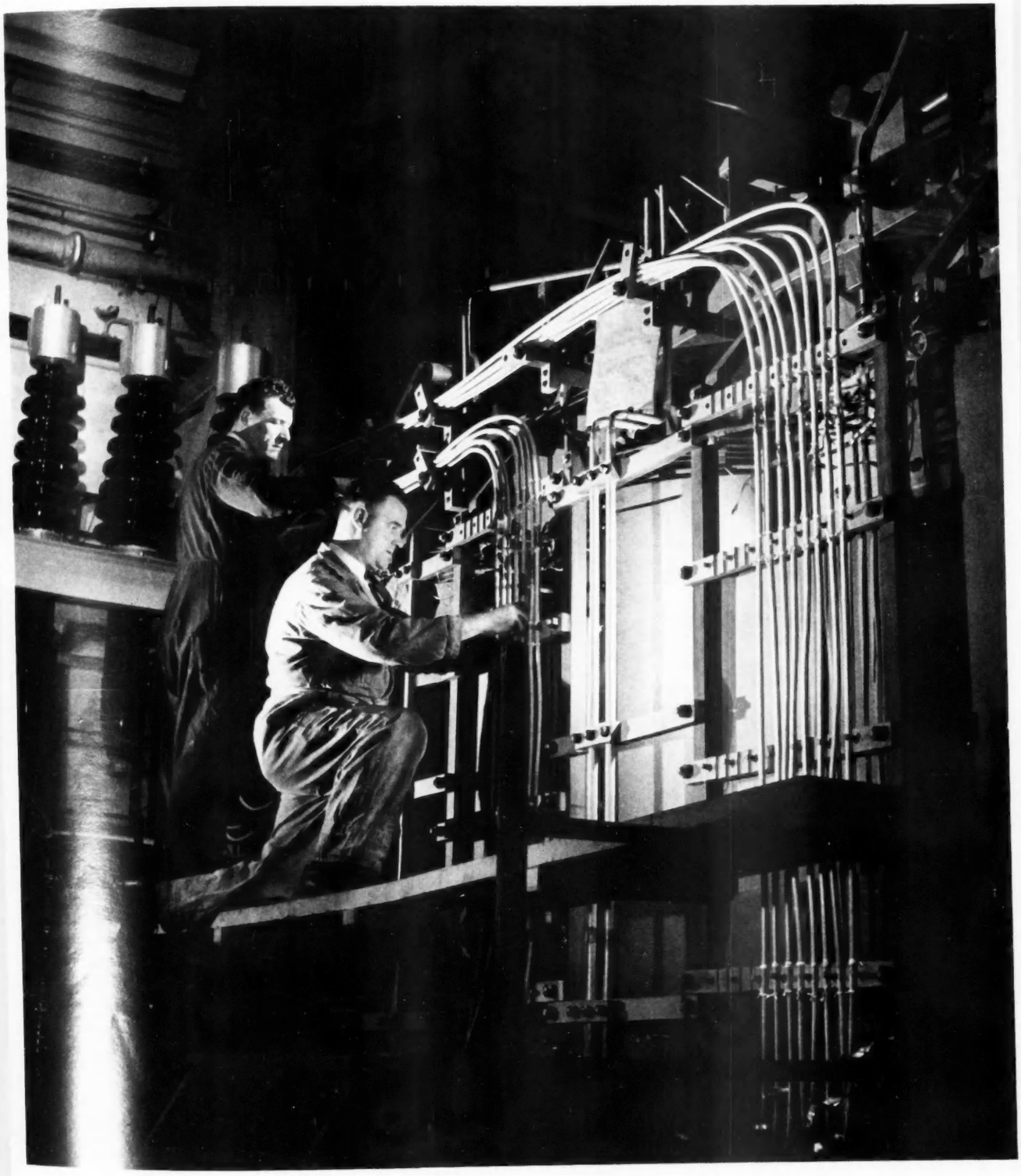

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A total of 65,500 ft. of 3-inch boiler tubes and 10,500 ft. of 1⅞ in. superheater tubes, were supplied for the five Spearing boilers at this refinery, for The British Petroleum Company Limited (previously A.I.O.C.).

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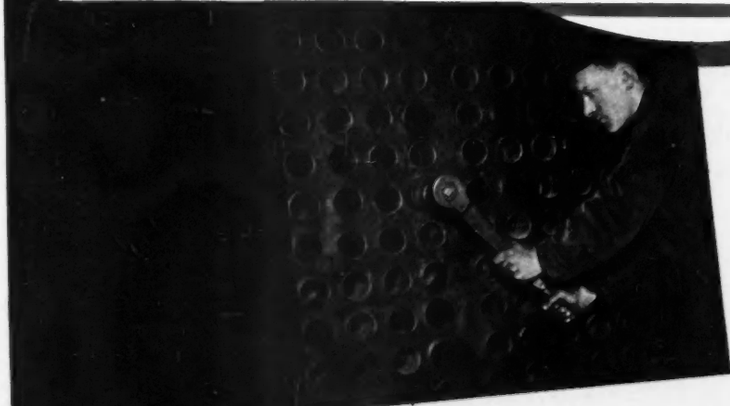
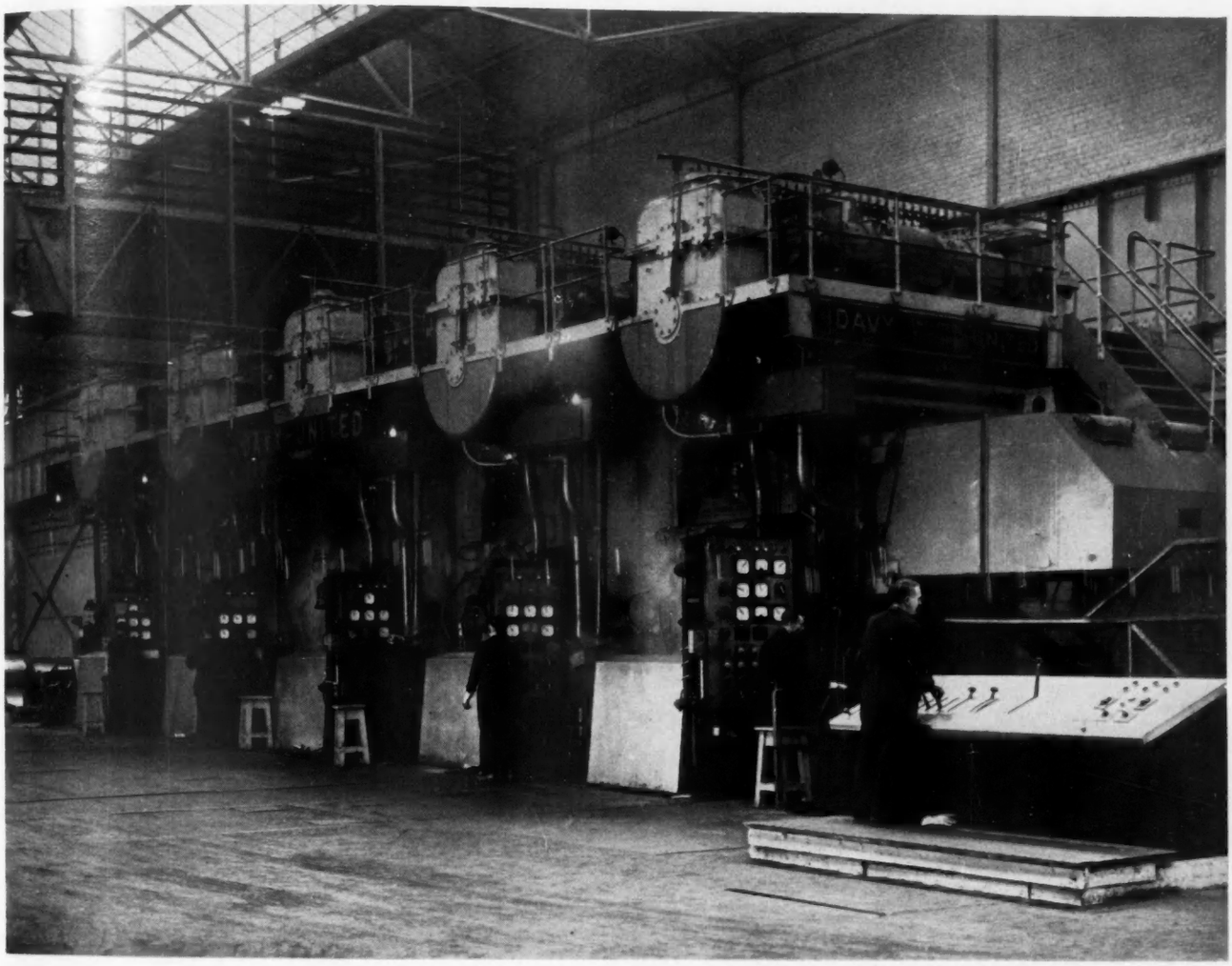


IN SHIPS' BOILERS

The main boilers of a ship being retubed with Stewarts and Lloyds' ERW tubes.



Photograph by courtesy of Richard Thomas & Baldwins Limited.

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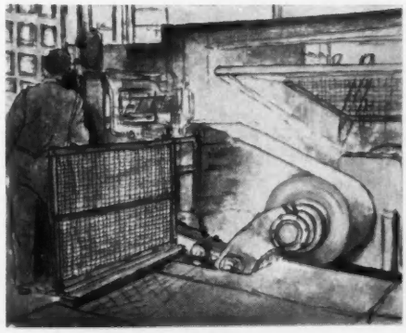

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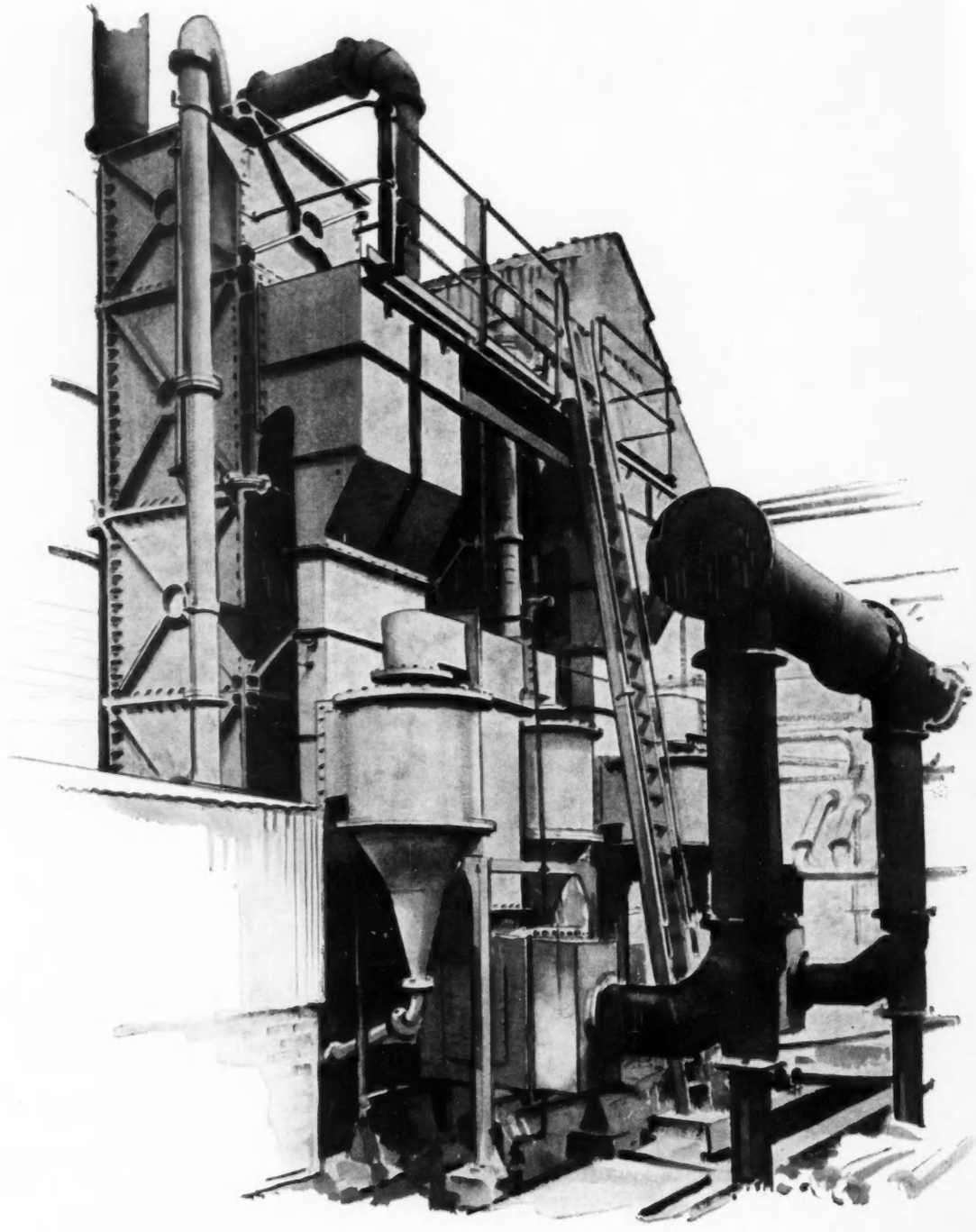

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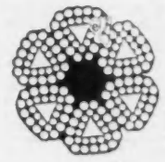

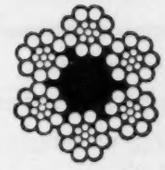

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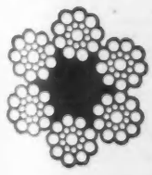

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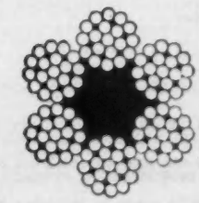

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For all advertisements classified under the headings of Tenders, Appointments Open, Situations Wanted, Patent Agents, Partnerships, Wanted, &c., Auction Sales, Publications For Sale, Miscellaneous and Public Notices, &c., the charge will be 12s. for the first four lines or under and 3s. per line up to one inch. When an advertisement measures an inch or more, the charge will be at the rate of 36s. per inch. 5% allowed on 6, 10% on 13, 15% on 26 and 20% on 52 Weekly insertions. If use is made of a box number the extra charge is 2s. per insertion with the exception of advertisements appearing under Situations Wanted. Prospectuses and Notices of Company Meetings £25 per column. Copy instructions must be in our hands first post Monday for the following Friday's issue. Address to the Manager, ENGINEERING LTD., 35 and 36, Bedford St., Strand, W.C.2 Inclusion of advertisements must be dependent on space being available.

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The 1956-57 Post-Graduate Course in Theory of Structures and Strength of Materials will be held in the Department of Engineering, Cambridge University, beginning on 9th October, 1956, and finishing in June, 1957.

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The object of the course is not to train research workers, but to help engineers to apply the latest advances in knowledge. The course will include lectures, colloquia and laboratory work, and each student will be encouraged to make a detailed study of some problem of particular interest to him.

The course is open to university graduates with industrial experience, and to others with suitable equivalent qualifications.

Further details and forms of application for admission may be obtained from THE SECRETARY, CAMBRIDGE UNIVERSITY ENGINEERING LABORATORY, TRUMPINGTON STREET, CAMBRIDGE. L 786

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The number of students will be limited and applications must reach the Secretary of the Engineering Laboratory not later than 1st July, 1956. Candidates should hold a degree in Engineering or a suitable alternative qualification and have had some practical training and experience. They will be required to attend for interview in Cambridge in July or August.

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THE IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

CITY AND GUILDS COLLEGE.
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Qualifications for admission are a degree in Mechanical Engineering or equivalent, preferably with some practical experience. A small number of postgraduate bursaries are available.

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Applicants should have served a recognised engineering apprenticeship. They should have a working knowledge of at least some of the equipment involved. Experience on engineering shift work in charge of ventilation plant and domestic services would be advantageous. Possession of O.N.C. or equivalent qualification is desirable.

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Chief Education Officer. L 794

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The Port of London Authority have a vacancy in their Drawing Office at Head Office, Trinity Square, E.C.3, for a

TECHNICAL ASSISTANT for the design and detailing of dock mechanical equipment, high pressure oil pumping systems and handling plant. Salary will be within the range of £600 to £890 per annum, the commencing salary being dependent on qualifications and experience.

Candidates must possess the Ordinary National Certificate or equivalent in appropriate subjects.

Applications, giving age, qualifications and full details of experience, should be addressed to the ESTABLISHMENT OFFICER, PORT OF LONDON AUTHORITY, TRINITY SQUARE, E.C.3. L 871

UNIVERSITY OF BIRMINGHAM.

APPOINTMENT OF SUPERINTENDENT OF BUILDINGS AND CHIEF ENGINEER.

Applications are invited for the appointment of Superintendent of Buildings and Chief Engineer, at a commencing salary upon the scale £900 to £1350 according to qualifications and experience.

Applicants should possess a recognised qualification and must have had a wide experience in the general maintenance of buildings and the running of both mechanical and electrical services. In addition they should be able to make drawings for small building works and services.

Applications (three copies), giving the names of three referees, should reach the undersigned (from whom further particulars may be obtained) not later than 30th June, 1956.

G. L. BARNES,
SECRETARY.
THE UNIVERSITY,
BIRMINGHAM, 15. L 806

UNIVERSITY OF CAMBRIDGE.

DEPARTMENT OF CHEMICAL ENGINEERING.

It is hoped soon to appoint an
ASSISTANT DIRECTOR OF RESEARCH in Chemical Engineering. The stipend is £1000 a year, rising by annual increments of £50 to £1350. Further particulars and forms of application from the Secretary of the APPOINTMENTS COMMITTEE, DEPARTMENT OF CHEMICAL ENGINEERING, TENNIS COURT ROAD, CAMBRIDGE, by whom applications must be received by 7th July, 1956. L 807

LONDON COUNTY COUNCIL.

ARCHITECT'S DEPARTMENT.

Vacancies for
ENGINEERING ASSISTANTS (up to £818) and **ENGINEER GRADE III** (up to £987) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from ARCHITECT (AR/EK/SE/1) THE COUNTY HALL, S.E.1. (1278). G 573

THE COLLEGE OF AERONAUTICS.

CHAIR OF AIRCRAFT ECONOMICS AND PRODUCTION.

The Governing Body invites application for appointment as
PROFESSOR AND HEAD OF THE DEPARTMENT OF AIRCRAFT ECONOMICS AND PRODUCTION at The College of Aeronautics. The salary scale will be in accord with the current range for professorial salaries obtaining in Universities, with superannuation under the Federated Superannuation System for Universities and family allowance. The salary on appointment will be dependent upon the qualifications and experience of the successful candidate. A house at a reasonable rent will be available if required.—Further details can be obtained from: THE RECORDER, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. L 817

CARMARTHENSHIRE EDUCATION COMMITTEE.

LLANELLY TECHNICAL COLLEGE.

Applications are invited for the post of
FULL-TIME ASSISTANT MASTER IN FOUNDRY WORK at the above-named College.

Candidates should be suitably qualified with experience of modern foundry practice, and be capable of conducting practical and theoretical classes in foundry work and science in preparation for the Intermediate and Final Certificates in Foundry Work of the City and Guilds of London Institute. Ability to teach Engineering Drawing will be an advantage.

Salary in accordance with the Burnham Further Education Report, 1954, for Grade B Assistants, including allowances for teaching and approved industrial experience.

Duties to commence on 1st September, 1956.

Further particulars and forms of application, which must be returned within two weeks of the appearance of this advertisement, may be obtained from the undersigned on receipt of a stamped addressed foolscap envelope.

IORWERTH HOWELLS,
DIRECTOR OF EDUCATION.
COUNTY EDUCATION OFFICES,
COUNTY HALL,
CARMARTHEN. L 812

LANCASHIRE EDUCATION COMMITTEE.

WIDNES EXCEPTED DISTRICT.

WIDNES COLLEGE OF FURTHER EDUCATION.

Applications are invited for the following appointments—

ENGINEERING DEPARTMENT—

(*a*) **LECTURER IN MECHANICAL ENGINEERING** subjects to H.N.C. standard.

(*b*) **LECTURER IN ELECTRICAL ENGINEERING** subjects to H.N.C. standard.

Applicants for either post should have degree or equivalent, and industrial and teaching experience. Salary in accordance with Burnham Technical Scale. The Engineering Department has new well-equipped laboratories and workshops.

Application forms from BOROUGH EDUCATION OFFICER, LUGSDALE ROAD, WIDNES, to be returned as soon as possible. L 830

DUNDEE TECHNICAL COLLEGE.

MECHANICAL ENGINEERING DEPARTMENT.

Applications are invited for the post of **LECTURER GRADE II.** Probable Salary Scales:—Grade II (a)—Honours Degree or Equivalent—£720 by £33 to £1050. Grade II (b) Other qualifications—£640 by £35 to £780 by £40 to £900. Both scales presently under revision.

Placing will be given on the appropriate scale for approved industrial and/or teaching experience.

Forms of application, which may be obtained from the CLERK AND TREASURER, DUNDEE INSTITUTE OF ART AND TECHNOLOGY, 40, BELL STREET, DUNDEE, should be returned not later than Friday, 8th June, 1956. L 835

FOOD INDUSTRY.

MECHANICAL ENGINEER required at Cambridge by the Food Investigation Organisation of D.S.I.R. Corporate Membership of Institution of Mechanical Engineers, *or* Honours degree in Mechanical Engineering. Candidates with experience in either refrigeration, food processing plant or drying equipment, *or* research experience of either heat transfer, low-speed aerodynamics, or drying processes. One year in Aberdeen to gain experience. Salary (under review) within range £1095-£1250. Equal Pay Scheme.—Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C842/5A. Closing date, 30th June, 1956. L 851

ENGINEER required at MINISTRY OF SUPPLY Headquarters, London, for work on design, development and testing of fuel systems and control equipment for aero gas turbine engines. Candidates should have a 1st or 2nd class honours degree or equivalent in Engineering. Appointment as Senior Scientific Officer (min. age 26 with at least 3 years' post graduate research experience, preferably in development work on aero engines) or Scientific Officer (min. age 21). Salary within ranges S.S.O. £1135-£1310; S.O. £539-£973 (Superannuable). Forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C 414/6A. L 852

CENTRAL ELECTRICITY AUTHORITY.
LONDON DIVISION.

ASSISTANT CIVIL ENGINEERS.

Applications are invited for Assistant Civil Engineers to work with an experienced team in the Chief Generation Engineer's (Construction) Department DIRECTLY CONCERNED with the design and construction of modern Power Stations. Opportunities exist to obtain the necessary qualifying experience for the Institution of Civil Engineers.

Frequent visits to sites will be part of normal duties.

Salary in ranges £693 to £908 p.a. and £850 10s. to £1085. (Ref. 56/392.)

Applications, quoting reference, should be made giving full details of age, experience etc., to DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1, within 10 days of this advertisement. L 781

HERTFORDSHIRE COUNTY COUNCIL.

WATFORD TECHNICAL COLLEGE.

Applications are invited for an **ASSISTANT GRADE B** to teach Mechanical Engineering subjects up to Higher National Certificate level. Candidates should have good academic qualifications and works experience. Salary on Burnham Technical Scale Grade B viz.:—

£525 by £25 to £820,

with appropriate additions for graduates and where applicable for approved periods of training and industrial experience.

Further particulars and forms of application obtainable from the PRINCIPAL, WATFORD TECHNICAL COLLEGE, HEMPSTEAD ROAD, to whom application should be returned as soon as possible. L 864

SOUTH OF SCOTLAND ELECTRICITY BOARD, GLASGOW AREA.

Applications are invited for the position of **SENIOR DRAUGHTSMAN** in the Glasgow Area: applicants should have experience in structural steel and reinforced concrete design and detail work, also the preparation of working drawings for general building construction: experience in architectural work would be an advantage: salary and conditions of service will be in accordance with the agreement of the National Joint Board for the Electricity Supply Industry: the salary will be within Schedule D, Grade 5 of that agreement, viz., £700 by £20 to £800 per annum with placing on the scale according to age and experience: the post is superannuable—Application forms which may be obtained from the undersigned should be returned not later than Monday, 25th June, 1956.

J. CAIRNS, SECRETARY.

P.O. BOX 6, 75 WATERLOO STREET, GLASGOW, C.2. L 861

ADMIRALTY.

ASSISTANT MECHANICAL (AUTOMOBILE) ENGINEER. The Civil Service Commissioners invite applications from men for this pensionable post in the Naval Store Department.

Age at least 25 and under 35 on 1st January, 1956, with extension for regular Forces' service and, up to two years, for established civil service.

Candidates must be corporate members of the Institution of Mechanical Engineers, or have passed (or be exempted from) the examinations necessary for corporate membership. Preference given to those who are members of the Automobile Division of the Institution. They must also have served an apprenticeship or have had post-graduate training in mechanical or automobile engineering and, in addition, had at least two years' practical experience on automobile engineering work.

Salary for a 45½-hour week in London from £800 at age 25 to £1099 at age 34 or over. Maximum £1252. Pay and conditions of service are under review. Promotion prospects.

Further particulars and application forms from CIVIL SERVICE COMMISSION, SCIENTIFIC BRANCH, 30, OLD BURLINGTON STREET, LONDON, W.1, quoting No. S 4592/56/12. Completed applications should be returned by 21st June, 1956. L 857

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

has a vacancy in the **TECHNICAL CLASS, GRADE II,** in the Outside Manufacturing Group of the

ENGINEERING SERVICES DIVISION.

Duties will include liaison with contractors in respect of orders for scientific instruments and apparatus, involving discussion of technical and production problems arising from such orders.

Applicants should have served a recognised mechanical engineering apprenticeship or have had equivalent training, and have a wide experience in manufacturing methods. Possession of an Ordinary National Certificate would be an advantage.

SALARY: £781-£925 p.a.

Contributory pension scheme; five-day week; excellent working conditions and generous leave allowances.

Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements or, alternatively, substantial assistance towards legal expenses incurred in house purchase will be available.

Send POST CARD for application form, which must be returned by 11th June, 1956, to ESTABLISHMENT OFFICER, A.E.R.E., HARWELL, DIDCOT, BERKS., quoting reference 560/26. L 772

NATIONAL COAL BOARD invite applications for superannuable appointments in the ENGINEERING DRAWING OFFICE of London Headquarters Production Dept. Salary according to qualifications and experience, within inclusive ranges as stated.

SENIOR DESIGNER DRAUGHTSMAN. H.N.C. or equivalent qualification is essential, and wide experience of mechanical design (preferably on colliery equipment). Applicants must be able to supervise the work of other draughtsmen, and the preparation of drawings connected with the standardisation of mechanical parts and equipment. £740-£1006 (Ref. No. 88/288).

SENIOR ENGINEERING DRAUGHTSMAN—3 POSTS (£866-£952).

(*a*) Wide experience in the design and layout of modern power stations, including ash and fuel handling equipment, is essential, with H.N.C. or equivalent qualifications (Ref. No. 88/289).

(*b*) Wide experience of mechanical equipment, preferably connected with colliery equipment, is essential, also ability to work on own initiative and, when required, to supervise the work of other draughtsmen. H.N.C. or equivalent qualification required (Ref. No. 88/290.)

(*c*) Experience is essential in the preparation of layouts for water treatment and sewage disposal plants of up to 30,000 galls. daily capacity, and for distribution schemes and drainage. Applicants must be able to work on own initiative and to supervise the work of other draughtsmen. Corporate Membership of I.P.H.E., or equivalent qualification is desirable (Ref. 88/291).

DESIGNER DRAUGHTSMAN. Experience of design and layout of power stations including fuel handling equipment is essential, with H.N.C. or equivalent qualification. £662-£794 (Ref. No. 88/292).

ENGINEERING DRAUGHTSMAN—3 POSTS (£662-£740), H.N.C. or equivalent qualification is essential with experience in either of the following fields:

(*a*) Preparation of water treatment and small sewage disposal plants (Ref. No. 88/293; or

(*b*) General mechanical, engineering and mechanisms (Ref. No. 88/294); or

(*c*) Electrical layouts, cabling and diagrams (Ref. No. 88/295).

Write, with full particulars of age, education, qualifications and experience, to NATIONAL COAL BOARD, STAFF DEPT., HOBART HOUSE, LONDON, S.W.1, MARKING ENVELOPE WITH RELEVANT 88 REF. NUMBER, before 29th June, 1956. L 856

ESSEX.

NORTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART, COLCHESTER.

ASSISTANT GRADE "A" required in September to teach **MECHANICAL AND/OR ELECTRICAL ENGINEERING** subjects up to Ordinary National Certificate standard. Good industrial experience essential.

Salary, £450 by £18 to £725 p.a. with additions for degree or equivalent qualification and training. Increments allowed for teaching, war/national service and approved industrial experience.

Details and forms (stamped addressed foolscap envelope) from the Clerk to the Governors, Divisional Education Office, Park Road, Colchester.

THURROCK TECHNICAL COLLEGE, GRAYS.
ASSISTANT GRADE "B" required in September to take charge of new WELDING Shop and to develop this subject. Initially the person appointed will also be required to assist materially with City and Guilds Machine Shop Engineering courses.

Salary, £525 by £25 to £820 p.a. with additions for degree or equivalent qualification and training. Increments allowed for teaching, war/national service and approved industrial experience.

Details and forms (stamped addressed foolscap envelope) from the Clerk to the Governors, Divisional Education Office, Upminster Court, Hall Lane, Upminster.

SOUTH-EAST ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART, LONGBRIDGE ROAD, DAGENHAM.

ASSISTANTS GRADE "B" required in September, if possible, for the following posts:—

(*a*) ELECTRICAL ENGINEERING, for National Certificate Electrical Installation and Electrical Technician Courses.

(*b*) MECHANICAL ENGINEERING. To teach Applied Mechanics and Engineering Drawing. Ability to offer Production Engineering subjects an advantage.

(*c*) PRODUCTION ENGINEERING, for National Certificate and City and Guilds Machine Shop Courses.

Salaries, £525 by £25 to £820 p.a. with additions for degree or equivalent qualification and training. Increments allowed for teaching, war/national service and approved industrial experience.

Details and forms (stamped addressed foolscap envelope) from the CLERK TO THE GOVERNORS AT THE COLLEGE, to whom completed applications should be returned within fourteen days of this advertisement. L 816

CENTRAL ELECTRICITY AUTHORITY.

SOUTH EASTERN DIVISION.

DEPUTY POWER STATION SUPERINTENDENT—BRIGHTON "A" AND "B" POWER STATIONS. Salary within the range of £1470 to £1575 in accordance with Class L Grade 3 of the N.J.B. Agreement. Applicants must have administrative ability, experience in the operation and maintenance of modern H.P. turbine and boiler plant and E.H.T. Switchgear; also experience in the control of labour. Corporate membership of the Institution of Electrical and/or Mechanical Engineers or equivalent qualifications desirable. Applications, giving full details of education, present appointment, experience, etc., should be sent to the POWER STATION SUPERINTENDENT, BRIGHTON, "B" POWER STATION, PORTSLADE BY SEA, SUSSEX, to arrive by 13th June, 1956. L 850

The Board of Trustees of the Port of Aden invite applications for the post of

ASSISTANT WORKSHOP SUPERINTENDENT (STORES). Candidates should be not more than 36 years of age, have served a recognised engineering apprenticeship, and be in possession of a 1st Class B.O.T. Steam Certificate of Competency. Preference will be given to candidates with a combined 1st Class Steam and Motor Certificate. Experience in the control and handling of stores is necessary as the successful candidates will, in the first instance, be required to take charge of a stores department and complete its re-organisation. Thereafter his time will be divided between the Workshop and stores. Salary £1200 per annum rising by increments of £50 to a maximum of £1700 per annum, if fully qualified.

Free unfurnished quarters are provided and free medical attention for the employee. A contributory medical benefit scheme covers dependants for a small charge.

Option is available to enter the service on short term contract for five years, comprising two tours, each two years abroad, followed by six months leave, with a gratuity of 10 per cent. of final annual salary for each year of service, or alternatively joining the Permanent Service on probation.

Option is also given of entering the Permanent Service of the Board subject to the Board's approval at the end of the five years' contract.

Full details and application forms may be obtained from the ADEN PORT TRUST CONSULTING ENGINEERS AND AGENTS, 1, LYGON PLACE, GROSVENOR GARDENS, LONDON, S.W.1. L 849

The Board of Trustees of the Port of Aden invite applications for the post of

DEPUTY WHARF SUPERINTENDENT. Candidates should be between the ages of 25 and 45 and have practical experience of work in a port, a good knowledge of accounts and should preferably be Members of the Institute of Transport. Salary, £1000 per annum rising by annual increments of £50 per annum to a maximum of £1600 per annum. The point of entry in the scale will depend on the qualifications and experience of the candidate.

Free unfurnished quarters are provided and free medical attention for the employee. A contributory medical benefit scheme covers dependants for a small charge.

Option is available to enter the service on short term contract for five years, comprising two tours, each two years aborad, bollowed by six months leave, with a gratuity of 10 per cent. of final annual salary for each year of service, or alternatively joining the Permanent Service on probation.

Option is also given of entering the Permanent Service of the Board subject to the Board's approval at the end of the five years' contract.

Full details and application forms may be obtained from the ADEN PORT TRUST CONSULTING ENGINEERS AND AGENTS, 1, LYGON PLACE, GROSVENOR GARDENS, LONDON, S.W.1. L 848

LONDON COUNTRY COUNCIL.

Wandsworth Technical College, September.
ASSISTANT GRADE A to teach Engineering Drawing, Engineering Science and allied subjects for National Certificate and City and Guilds courses in Mechanical Engineering. Graduate or equivalent qualifications, industrial and teaching experience desirable. Burnham salary scale (now under review), £450 by £18 to £839), plus London allowance of £36 or £48, commencing and maximum salary according to age, qualifications and experience.—Application forms from SECRETARY AT COLLEGE, WANDSWORTH HIGH STREET, S.W.18, returnable by 16th June (954). L 775

LONDON COUNY COUNCIL.

South East London Technical College, September, 1956.
LECTURER, mainly to teach Strength of Materials and Applied Mechanics to students in Courses for Higher National Certificates in Mechanical Engineering. Should be graduates of a British University and preferably also Corporate Members of the Institution of Mechanical Engineers. Burnham F.E. salary scale (at present under review), £1001 by £25 to £1113.—Application forms from SECRETARY AT COLLEGE, LEWISHAM WAY, S.E.4, returnable by 16th JUNE, 1956. (965.) L 780

CENTRAL ELECTRICITY AUTHORITY.
LONDON DIVISION.

DRAUGHTSMEN.

Applications are invited for Draughtsmen to work in an experienced team in the Chief Generation Engineer's (Construction) Department, covering CIVIL, ELECTRICAL and MECHANICAL aspects in the design and development of modern Power Stations. Periodic VISITS TO SITES will be part of normal duties. There is every SCOPE FOR ADVANCEMENT for the right men.

Salary ranges as follows:—
Civil: £588 to £714.
£850 to £955.
Electrical: £588 to £840.
Mechanical: £588 to £955.

Applications should be made to DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1, or ring Victoria 6886, Ext. 21, for appointment. L 782

BRITISH RAILWAYS (WESTERN REGION), SWINDON, require the immediate services of an **ELECTRICAL ENGINEER** with practical and Drawing Office experience.

Knowledge of design and layout of Electric control circuits and auxiliaries for Diesel locomotives essential.

Salary, £770-£835. Free and Privilege travel facilities. Sick pay during absence owing to ill-health. Superannuation Scheme.

Apply in writing, giving full particulars of experience to:—
CHIEF MECHANICAL AND ELECTRICAL ENGINEER,
ROOM 13,
BRITISH RAILWAYS (WESTERN REGION),
SWINDON, WILTS. L 785

CENTRAL ELECTRICITY AUTHORITY.
MIDLANDS DIVISION.

Applications are invited for the following positions in the Generation Construction Department at Divisional Headquarters, Moseley, Birmingham. Good working conditions, superannuable appointments, salaries within the range £700 to £910 per annum, dependent upon qualifications and experience :—

(a) **SENIOR DRAUGHTSMAN** (Mechanical), Vacancy No. 340MD.
(b) **SENIOR DRAUGHTSMAN** (Mechanical), Vacancy No. 341MD.

Applicants should have a sound technical training and experience appropriate to the position applied for, i.e., the layout of either

(a) boilers, ash and coal handling plant, factory services and ancillary equipment, or
(b) turbo-alternator, heavy pumping plant, H.P. steam and feed pipework, and ancillary equipment,

preferably, but not essentially, associated with power station, chemical or other heavy industrial plant.

The Division is responsible for the installation of power station plant of advanced design, offering a variety of interesting, and frequently novel, work.

Apply, quoting the vacancy number, on form AE6, available from the ESTABLISHMENTS OFFICER, 53, WAKE GREEN ROAD, MOSELEY, BIRMINGHAM, 13, by 15th JUNE, 1956. L 784

CENTRAL ELECTRICITY AUTHORITY.
LONDON DIVISION.

ASSISTANT ELECTRICAL ENGINEER.

Applications are invited for an Assistant Electrical Engineer to work with an experienced team in the Chief Generation Engineer's (Construction) Department DIRECTLY CONCERNED with the construction of modern Power Stations. Candidates should have sound practical training in Electrical Engineering. Experience in design, manufacture and installation of Power Station plant together with preparation of specifications and estimates would be an advantage. Salary in range £850 10s. to £1085 p.a.—Applications, quoting vacancy No. 56/222, should be made, giving full details of age, experience, etc., to DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1. L 783

PUBLIC NOTICE.

UNIVERSITY OF GLASGOW.

RESEARCH FELLOWSHIP IN AERONAUTICS.

Applications are invited for a Research Fellowship in Aeronautics established by the English Electric Company in the University of Glasgow. The Fellowship is intended to provide for a graduate in Engineering or Applied Science the opportunity to spend a year in advanced study and research in Aeronautics. The value of the Fellowship will be £500 per annum, though consideration will be given to the payment of a higher award to a successful candidate with previous experience in aircraft engineering practice. Tenure will begin on 1st September, 1956. Applications (3 copies), with a statement of experience and the names of three referees, should be lodged, with the undersigned, not later than 23rd June, 1956.

ROBT. T. HUTCHESON,
Secretary of University Court. L 779

APPOINTMENTS OPEN.

PLANNING ENGINEER required, experienced in Estimating, Planning and Ratefixing for medium size Production Machine Shop. Excellent Pension Scheme operated. State experience, age and salary required to—PERSONNEL MANAGER, KENT ALLOYS, LIMITED, STROOD, ROCHESTER, KENT. L 592

Classified Advertisements continued on Page 4

MECHANICAL ENGINEERS

A large and well-known Company in the North of England offers the following attractive working conditions:—

1. Starting salaries up to £1300 p.a.
2. An Engineering career with outstanding opportunities in an expanding industry.
3. An opportunity for the young engineer to obtain varied experience in Research, Design, Construction, Maintenance, Work Study.
4. Post-graduate training when necessary with full staff salary.
5. Specialist appointments in the Research field for those suitably qualified.
6. A congenial working atmosphere and unexcelled welfare facilities.
7. A job in an area comparing favourably with any in England.

If you have a University degree or a professional qualification, we shall be pleased to hear from you. Whilst we prefer men in their twenties, we have a number of vacancies suitable for experienced men up to 35 years of age.

Write, giving a brief summary of your qualifications and experience, to BOX L 808, Offices of ENGINEERING, quoting reference P.6.

DRAUGHTSMAN required for Engine Design Schemes on small high-speed diesels must have initiative and experience. Good salary. Pleasant working conditions. Pension Scheme.—Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES. G 650

ASSISTANT ELECTRICAL ENGINEER required for extensive developments at a large Iron and Steel Works in the Midlands. H.N.C. or degree qualification in electrical engineering, with experience in heavy industry desirable but not essential. Housing prospects favourable.—Applicants should give details of experience and of salary required.—Apply to BOX L 705, Offices of ENGINEERING.

BLAW KNOX LIMITED with expanding export business in Excavators and varied Construction Equipment have vacancies in their Watford Office for a few

DRAUGHTSMEN, preferably experienced in Mechanical and Constructional Design.—Write or 'Phone: PERSONNEL MANAGER, BLAW KNOX LIMITED, WATFORD. (Telephone: Watford 9291.) L 741

STRUCTURAL ENGINEER required by London firm of Consultants to take charge of their steel design office. Candidates must have a comprehensive knowledge of all types of structural steelwork both designing and detailing and should preferably have had some works experience. Applicants should be Corporate Members of one of the senior professional Institutions or hold similar Degrees. The post is a permanent one and there is a Staff Pension Scheme.—Please reply in confidence to BOX NO. 389, GLOVERS ADVERTISING, LTD., 351, OXFORD STREET, W.1. G 643

QUALIFIED ENGINEER with Commercial experience required by Exporters for their expanding engineering business. Must be able to negotiate technically and commercially. Good salary and prospects. West End offices.—Please apply BOX L 687, Offices of ENGINEERING.

SENIOR AND JUNIOR STRUCTURAL DESIGNERS required for busy London office handling a wide variety of building schemes. Considerable scope for advancement is available to reliable man with initiative who can work with the minimum supervision and deal with site matters.—BOX L 838, Offices of ENGINEERING.

WILTON ICI WORKS

ENGINEERING DESIGNERS

The construction of the Company's factory at Wilton on a 2000-acre site has proceeded continuously since 1946 and now over ten million pounds are spent each year on new works. Staff with experience in design of modern works are required for this development.

The immediate vacancies are in the Design Office for :—

ASSISTANT TECHNICAL OFFICERS
MECHANICAL ELECTRICAL
CIVIL STRUCTURAL
INSTRUMENT

The appointments are to permanent staff and the Company is anxious to engage men who have had first rate experience to assist with the long-term plans for further development. Candidates in this category will be invited to interview, without commitment, at the Company's expense.

SALARIES
Commencing salaries up to £900 per annum will depend on the age and experience of candidates. The salaries of men engaged will be reviewed annually.

TERMS OF EMPLOYMENT
Five-day, 39-hour working week, Pension Fund, Profit Sharing Scheme, etc.

HOUSING
After joining the staff married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available in approved cases for substantial loans; in addition, legal charges will be advanced.

Assistance is given in the procuring of rented houses, flats or lodgings.

Wilton is situated at the foot of the Cleveland Hills in Yorkshire, five miles from the coast. Working conditions are good and recreation facilities, including golf, tennis and badminton, are available.

Write for application form to: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting advertisement reference ICI/X/302/e. L 541

ENGINEER of outstanding ability required having practical experience in general engineering; preferably with degree or Membership of Institution. Excellent prospects with Group manufacturing bricks, cement and other building materials. Salary in accordance with experience and qualifications. Age preferably 35-45.—Reply giving full details in chronological order, to PRODUCTION DIRECTOR, EASTWOODS, LTD., 158, CITY ROAD, E.C.1. L 757

ESTIMATOR required, London area. Heavy Mechanical Engineering experience and knowledge of gearing essential.—Write giving full details of experience, salary required and age to: THE SECRETARY, THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON, MIDDLESEX. Property for rental would be made available to suitable applicant. L 680

AERO ENGINE CONTROL SYSTEM.

ENGINEERS are required for a newly formed department dealing with various theoretical aspects of aero engine control problems. Experience of servo mechanism analysis and gas turbine engine performance investigation is desirable.—Applications quoting END to TECHNICAL PERSONNEL MANAGER, ARMSTRONG SIDDELEY MOTORS, COVENTRY. G 658

EXPERIENCED PLANNING ENGINEERS required for production methods on medium I.C. engine components and fuel injection equipment. Pleasant working conditions, generous salary. Attractive Pension Scheme and Comprehensive Welfare Facilities.
Apply CHIEF PERSONNEL OFFICER, PETTERS LIMITED, CAUSEWAY WORKS, STAINES, MIDDX. G 662A

WANTED

DRAUGHTSMEN to design in aluminium for sales development. Must possess Higher National Certificate in Mechanical Engineering. Location Banbury. Good working conditions and pleasant surroundings. Attractive starting salaries offered up to £800 p.a. with prospects of promotion from drawing board. Pension plan in operation. Send brief details of qualifications and experience to NORTHERN ALUMINIUM CO., LTD., BUSH HOUSE, ALDWYCH, LONDON, W.C.2. G 662

SENIOR DRAUGHTSMAN required, London area. Heavy Mechanical Engineering experience essential, knowledge of gearing an advantage.—Write stating age and salary required and giving full details of experience to THE SECRETARY, THE POWER PLANT COMPANY, LIMITED, WEST DRAYTON, MIDDLESEX. Property for rental would be made available to suitable applicant. L 681

Marine Engineering Company constructing main steam turbines and diesel machinery, watertube boilers, etc., for largest sizes of warships, passenger ships and oil tankers requires a

GENERAL MANAGER to supervise the Works and to be responsible for production to the Managing Director.—Applicants please state age, qualifications, experience and an indication of salary required to BOX L 715, Offices of ENGINEERING.

ENGINEERING DRAUGHTSMEN, preferably with mechanical or electrical experience, required for established chemical and process engineers. Approximately six months in North Gloucestershire and then permanently at North-West Surrey. Good salary, prospects and canteen. Five-day week. —Apply BOX L 695, Offices of ENGINEERING.

VICKERS-ARMSTRONGS (ENGINEERS) LIMITED
BARROW-IN-FURNESS, LANCASHIRE

Are seeking technical staff, as under, for research and development work in connection with the application of new methods to the propulsion of ships.

ENGINEERS

Engineers holding Honours Degrees with experience in the field of marine or mechanical engineering.

DRAUGHTSMEN

Men who have completed their National Service, for work in connection with the above, and also for the general development of prototypes, and the production and installation of machinery.

TEST ENGINEER

For marine research work. A minimum standard of H.N.C. is required, and sea-going experience with Board of Trade Certificate will be a distinct advantage.

The above requirements offer a splendid opportunity to the right type of men, and good salaries will be paid in accordance with experience, ability and training.

The Barrow district is an extremely pleasant one in which to reside, offering the close proximity of sea, countryside and the Lake District. In suitable circumstances, housing accommodation may be available if required by successful applicants, and a contributory pension scheme is in operation.

Sporting and social facilities are excellent, providing a wide variety of activities on a large and well appointed sports ground.

Applications giving full details, should be sent to the Labour Manager at the above address. L 642

Excellent Opportunities For MECHANICAL & ELECTRICAL ENGINEERS *in the United States of America*

Hughes, one of America's leaders in the field of advanced electronics has openings for Mechanical and Electrical Engineers. These Engineers must have degrees and six or more years' experience in developing servo-mechanisms and/or electronic controls. Hughes, located on the West Coast of the U.S.A., offers Engineers opportunity, challenge, and reward.

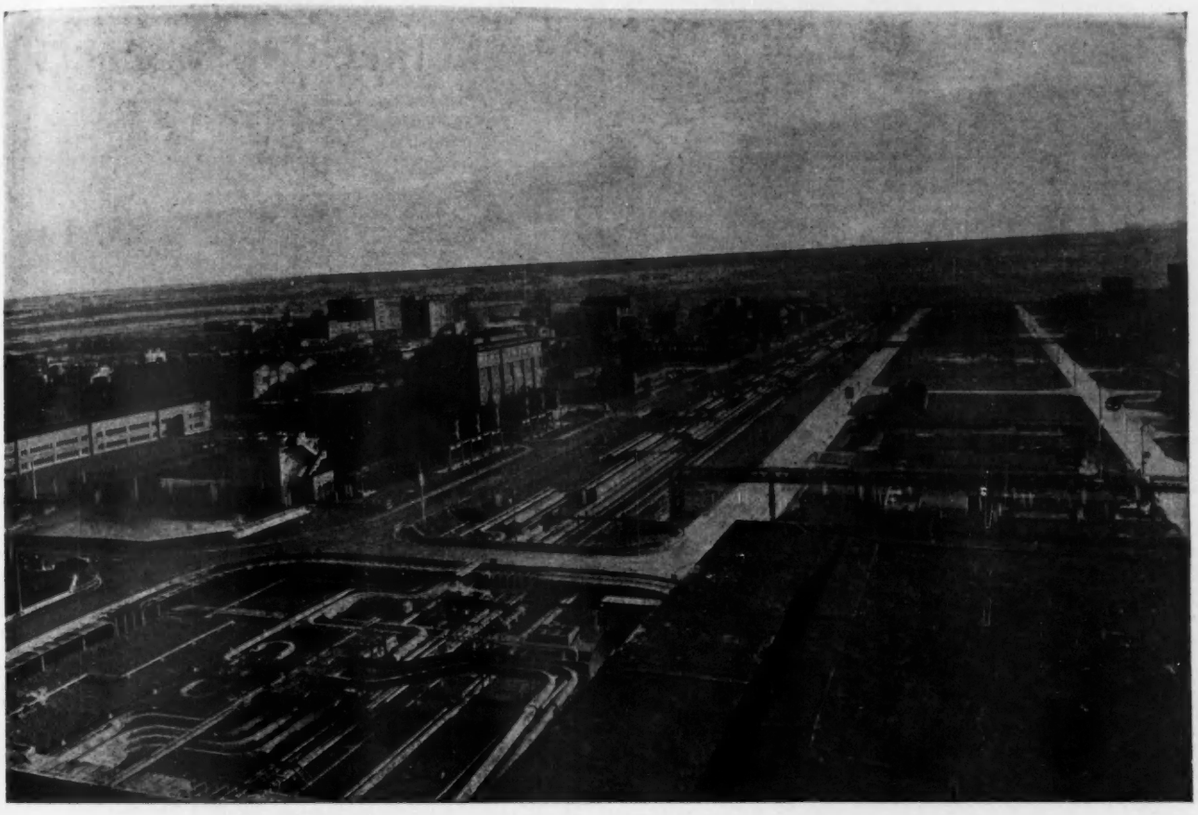
London and Manchester interviews in June.

For interview, air mail resume to

HUGHES PRODUCTS

A DIVISION OF THE HUGHES AIRCRAFT CO., 5440 W. CENTURY BOULEVARD, LOS ANGELES 45, CALIFORNIA, U.S.A. ATTENTION: M. MAY. L 777

YOUR ROAD TO SUCCESS



Central Avenue, Wilton Works, Yorkshire

If you are aged 30 or under, have completed National Service, possess an Honours Degree and are either a Mechanical, Electrical or Instrument Engineer, then a post may await you at WILTON WORKS, working either on design and layout, construction, plant operation or maintenance.

Starting salaries are good.

WILTON WORKS is the largest post-war project of the British Chemical Industry. Since 1946 over £50 millions have been spent and development of the 2,000 acre site, which lies outside the industrial smoke belt, is being continuously expanded at the rate of over £1m. a month.

As befits this most modern of factories, working conditions are first class. So, too, are the recreational facilities — WILTON WORKS even possesses its own nine-hole golf course!

For a well-paid career, a job worth doing and a fine opportunity of rapid advancement, write TO-DAY to: Staff Manager, Imperial Chemical Industries Limited, Wilton Works, Middlesbrough, Yorkshire, quoting advertisement reference. ICI/X/310A.

WILTON ICI WORKS

THERE ARE OPENINGS **NOW** FOR
MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS
INSTRUMENT ENGINEERS

IMPERIAL CHEMICAL INDUSTRIES LIMITED

L 796

Classified Advertisements continued on Page 6

IMPERIAL CHEMICAL INDUSTRIES LIMITED.
METALS DIVISION.

TECHNICAL OFFICER

KIRKBY WORKS.

The new Kirkby Works of Imperial Chemical Industries is the largest copper tube factory in the British Commonwealth, equipped with modern and powerful tube drawing machinery. It is situated five miles east of Liverpool on the East Lancashire Road.

A Technical Officer is required to prepare and handle development projects and to translate successful projects into works practice.

Applicants should be graduates of a British University in either metallurgy or engineering, and preferably, although not necessarily, have had three or four years experience in industry concerned with the fabrication of metals.

Excellent conditions of employment include a generous starting salary, with adequate scope for progressive remuneration, a 5-day week, contributory Pension Fund and a Profit Sharing Scheme. Married men will receive a reasonable refund of their removal (including travel) expenses, and, in approved cases, facilities are available to assist them in house purchase.

Application forms may be obtained from STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, KYNOCH WORKS, WITTON, BIRMINGHAM, 6, quoting KTO/1/ENG. L 819

BILLINGHAM ICI DIVISION

Vacancies in

ENGINEERING RESEARCH DEPARTMENT

BILLINGHAM.

Applications are invited from Engineers, Physicists and Mathematicians for appointments as Technical Officers in the Engineering Research Department of the Billingham Division. The work will be of a specialist nature and candidates should preferably have already had experience on vibration. Current problems are connected with structural and foundation vibrations, pulsations in flowing fluids, torsional oscillations of crankshafts and aerodynamic noise. Publication of results of general interest is encouraged.

These appointments are permanent and pensionable and carry attractive salaries. There is also a profit-sharing scheme in operation. Assistance can be given towards house purchase and removal expenses in the case of married men.

Write, giving brief details of age, qualifications and experience to the Staff Manager, Imperial Chemical Industries Limited, Billingham Division, Billingham, Co. Durham, quoting reference M.5. L 749

DRAUGHTSMEN (SENIOR AND JUNIOR) required for work in connection with the following branches of Coke Oven and Gasworks plants.
(*a*) Mechanical and By-Product Plant.
(*b*) Pipework.
(*c*) Steelwork for Buildings and Conveyors.
Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; Canteen Facilities.—State age and experience to the PERSONNEL OFFICER (D.O.), WOODALL-DUCKHAM CONSTRUCTION COMPANY LTD., WOODALL-DUCKHAM HOUSE, 63-77, BROMPTON ROAD, LONDON, S.W.3. G 550

UNILEVER LIMITED invite applications for an appointment in the Engineering Department of their London Office as a
STEAM SPECIALIST. Candidates should be not more than 40 years of age and Corporate Members of the Institution of Mechanical Engineers. They should have had theoretical and practical experience of the thermal design and operation of shell and water tube boiler plant with solid and liquid fuels and of steam distribution systems. Some knowledge of water treatment would be of advantage. Written applications giving full particulars of qualifications, training and experience to be addressed to: UNILEVER LTD., PERSONNEL DIVISION (WAD 115), UNILEVER HOUSE, BLACKFRIARS, LONDON E.C.4. L 872

QUALIFIED ENGINEER, 35/45, required to manage London purchasing office (two technical assistants plus clerical staff). Essential qualifications, wide general knowledge mechanical electrical plant, comprehensive commercial experience and personality to meet Principals and Suppliers at high level. Applicant must be able to deal with large volume of enquiries from overseas territories, including handling exclusive agencies and co-ordination important contracts. Some travelling required. Salary £1700 plus bonus.—Write BOX MA/93, c/o 95, BISHOPSGATE, E.C.2. L 755

SENIOR JIG AND TOOL DRAUGHTSMEN required for Tool Design on
(*a*) Small I.C. Engine components.
(*b*) Fuel Injection and Hydraulic Control Mechanisms on a production basis.
Applicants should have experience in these or similar fields.
Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.
Apply to CHIEF PERSONNEL OFFICER, BRYCE BERGER WORKS, STAINES, MIDDX. G 660

BRUSH ELECTRICAL ENGINEERING CO., LTD., have vacancies for men of ambition seeking progressive and responsible positions as
TENDERING AND CONTRACTS ENGINEERS in their Commercial Departments at Loughborough. Applicants should be capable correspondents with experience in one or more of the following: turbo-alternators, rotating machines, switchgear or transformers. Additionally, vacancies exist in the General Engineering Division for men having specialised knowledge of comprehensive power schemes for both diesel and steam generating stations. Appointments will be of a permanent nature with good salaries, and excellent prospects are open to suitable men. Conditions of service include non-contributory staff assurance.—Please write with full details in confidence to the CHIEF PERSONNEL OFFICER, BRUSH ELECTRICAL ENGINEERING CO., LTD., LOUGHBOROUGH, LEICS. L 764

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations, A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter giving details of technical education to the CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. G 665

Vickers-Armstrongs (Aircraft) Ltd., Weybridge, Surrey,

have a vacancy for a

FIRST CLASS AIR CONDITIONING DESIGN ENGINEER,

to be responsible for Aircraft Pressurizing, Ventilating & Refrigerating Systems.

The post is of

SENIOR EXECUTIVE STATUS

with excellent prospects of advancement.

Vickers-Armstrongs (Aircraft) Ltd.,

also have a vacancy with good prospects of Advancement for a

FIRST CLASS HYDRAULICS DESIGN ENGINEER

for Aircraft Systems.

Applications should be addressed to:

The Chief Designer
Vickers-Armstrongs (Aircraft) Ltd.,
Weybridge, Surrey.

L 823

IMPERIAL CHEMICAL INDUSTRIES LIMITED.
METALS DIVISION.

Applications are invited for several senior positions as

PROJECT OFFICERS

in the

TECHNICAL DEPARTMENT

Located at Witton, Birmingham.

Duties will entail the consideration of both the technical and commercial aspects of proposals to provide new or improved facilities for the melting, casting and preliminary fabrication of wrought non-ferrous products, including titanium. This will involve an appreciation and keen interest in the activities of other departments, inc. Research, Engineering, Production, Accountancy and Sales. These liaison duties will enable the successful candidates to acquire a comprehensive experience of industrial activities in general.

Applicants, between the ages of 28 and 40, should possess an Honours Degree in Physics, Metallurgy, Engineering or Mathematics. Experience in industry is essential but appropriate further training, if necessary, will be arranged.

These positions offer most attractive salary prospects and will only be offered to men of outstanding ability.

Excellent conditions of employment include a contributory Staff Pension Fund and a Profit Sharing Scheme. After joining the staff, married men will receive a reasonable refund of removal (including travel) expenses, and to assist them in house purchase, facilities are available, in approved cases, for loans.

Applications, giving brief details of career to date, should be addressed to the STAFF MANAGER, I.C.I. METALS DIVISION, KYNOCH WORKS, WITTON, BIRMINGHAM, 6, quoting TD/1-ENG. L 820

JIG AND TOOL DRAUGHTSMEN

required by a medium/large modern engineering works engaged in the machining and assembling of Automobile Components. Applicants must have served an apprenticeship and have obtained the Ordinary National Certificate. Good salary and conditions; Pension Scheme; Sports Club and opportunities for advancement.

Rented housing accommodation available in the New Town for successful applicants.

Write in the first instance to

LABOUR MANAGER,
ALFORD & ALDER (ENGINEERS) LTD.,
MAYLANDS AVENUE, HEMEL HEMPSTEAD, HERTS. L 829

GRADUATE ENGINEER (MECHANICAL OR ELECTRICAL) with sound practical background and several years experience as an Industrial Engineer (Consultant or otherwise) required by a large Company in the Electrical Industry with headquarters in South Lancs. Age preferably 30/35. An attractive and responsible post suitably remunerated.—BOX L 844, Offices of ENGINEERING.

LADY TRACERS required in Consultants office near Victoria. Work involved covers all branches of Civil and Mechanical Engineering. Experience in plotting field survey work would be an advantage. Hours 9.30-5.30. Saturday morning duty one in six and two weeks paid holiday.—Apply SIR BRUCE WHITE, WOLFE BARRY & PARTNERS, 1, LYGON PLACE, S.W.1. SLOane 0431. L 789

G.E.C. STANMORE LABORATORIES

require a

CHIEF INSPECTOR

for the Engineering Development Group for work on Guided Weapon and Radar Projects.

Applicants should have had responsible experience of inspection in the Electronics industry both on the production line and at the stage of final test, and be well versed in A.I.D. procedure. A good knowledge of precision mechanical and electrical equipment, including microwave components, is essential. Familiarity with metallurgical, metal finishing and resin casting processes would be of particular advantage. Apply in writing, giving full details of education, qualifications and experience to the

STAFF MANAGER, THE GROVE, STANMORE COMMON, MIDDLESEX, QUOTING REF. E/JEM. L 756

Consulting Engineers require
TWO FIRST-CLASS TECHNICAL ENGINEERS for work on Nuclear Power Station projects. Previous experience of nuclear work is not expected, but a first-class academic record and subsequent practical experience in the mechanical, chemical or electrical engineering field is essential.

Salary range, £900-£1200.

Apply to KENNEDY & DONKIN, 12, CAXTON STREET, LONDON, S.W.1, quoting reference JMK. L 790

BRITISH PETROLEUM COMPANY has a vacancy for an
ENGINEERING ESTIMATOR for work in London, with occasional visits abroad. Age 30-35. Mechanical or Civil Engineering degree or equivalent. Applicants should also have served an engineering apprenticeship and had experience in estimating major projects for large engineering organisation. Salary according to age, qualifications and experience.—Applicants should write, stating age, qualifications, etc., quoting H.3620, to BOX 8933, c/o 191, GRESHAM HOUSE, E.C.2. L 791

A LEADING FIRM OF MANAGEMENT CONSULTANTS requires
QUALIFIED ENGINEERS with management experience. The work which is extremely interesting and of a consulting nature, offers exceptional prospects to men of mature personality and resourceful outlook.

Applicants to be aged 28 to 40 years with an engineering degree, having served an engineering apprenticeship and had executive experience.

Starting salary, which is in the four-figure range, increases annually after a training period appropriate to the individual. Non-contributory superannuation life assurance and a profit sharing schemes are included in total remuneration.—Write, with full particulars, to BOX L 834, Offices of ENGINEERING.

IMPERIAL CHEMICAL INDUSTRIES LIMITED,
METALS DIVISION.

METALLURGICAL ABSTRACTOR

A technical abstractor is required by the Metals Division of Imperial Chemical Industries Limited, to assist in the production of a monthly literature bulletin on titanium. Applicants should have suitable academic qualifications and a knowledge of theoretical and practical metallurgy. Ability to write clearly and precis accurately is essential and a knowledge of languages is desirable.

Excellent conditions of employment include a generous starting salary, a five-day week, contributory Pension Fund and Profit Sharing Scheme; in addition married men will receive a reasonable refund of all removal (including travel) expenses.

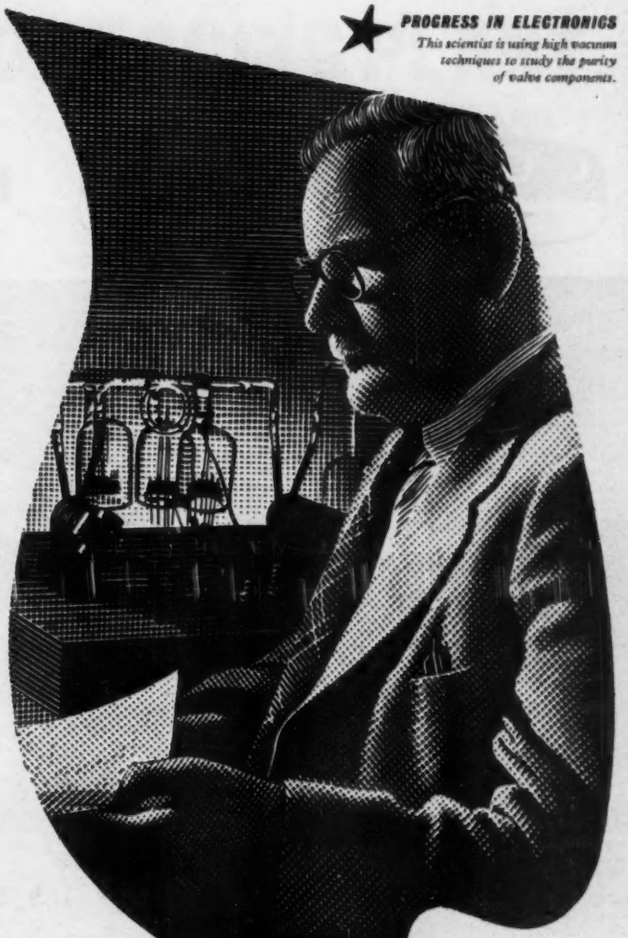
Application forms may be obtained from the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, METALS DIVISION, KYNOCH WORKS, WITTON, BIRMINGHAM 6, quoting MA/1/ENG. L 818

SALESMAN WITH TECHNICAL BACKGROUND, preferably in engineering or chemical industries required for pipe-fittings firm.—Applicants to be located in London. Good salary, superannuation scheme, etc.—BOX L 776, Offices of ENGINEERING.

DRAUGHTSMAN required with some experience of Shell Type Boilers and Boiler Installation. Country district, salmon and trout fishing in River Annan. Powfoot Golf Course two miles away. Apply, stating age, experience and salary required, to:—COCHRAN & CO., ANNAN, LTD., ANNAN, DUMFRIESSHIRE, SCOTLAND. L 840

Classified Advertisements continued on Page 123

★ ***PROGRESS IN ELECTRONICS***
This scientist is using high vacuum techniques to study the purity of valve components.



thought for tomorrow

Sometime in the future the results of this man's research will be applied to the solution of a production problem. The outcome may be a better quality product, or a cheaper product, or a better method of analysis or control.

You yourself may benefit from his work, for the chances are that in your industry, too, electronics has an increasingly important part to play.

Mullard scientists work hand in hand with the designers of Britain's leading electronic equipment manufacturers, and this combination helps to produce the finest equipment in the world. You can invest in it with confidence, for nowhere else will you find greater efficiency and reliability.

Mullard

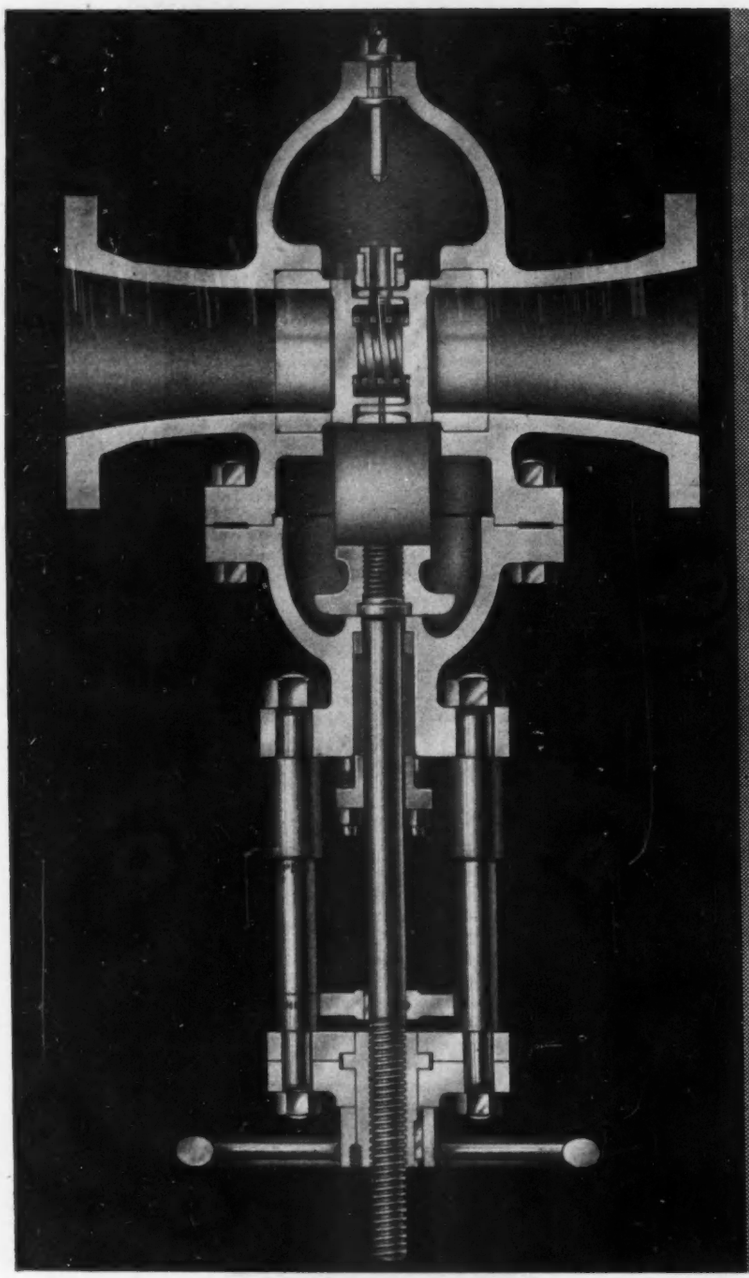
ELECTRONIC VALVES AND TUBES · SEMI-CONDUCTOR DEVICES · MAGNETIC COMPONENTS · SPECIALISED ELECTRONIC APPARATUS · FINE WIRE

MULLARD LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

MP524E

COCKBURNS VALVES

MASTERY OF STEAM

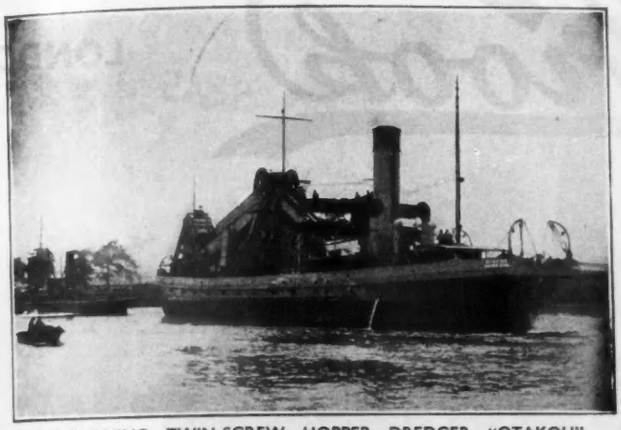


STREAMLINE PARALLEL SLIDE VALVE

Streamline formation of chest allows reduced valve orifice, with minimum pressure-drop characteristic. This design permits a valve of reduced size and weight. Lids are bound in open position—no fluttering. All parts readily accessible for overhaul.

COCKBURNS LTD • CARDONALD • GLASGOW S.W.2

SERVICE AND MAINTENANCE DEPOT AT 45 BACK UNION ROAD, FISH QUAY, NORTH SHIELDS



OIL-BURNING TWIN-SCREW HOPPER DREDGER "OTAKOU"
constructed for the
OTAGO HARBOUR BOARD, DUNEDIN, NEW ZEALAND.
Dimensions: 258 ft. × 20 ft. Hopper capacity 2,000 tons.
Speed loaded: 9½ knots. Dredging capacity per hour: 1,000 tons.

DREDGING PLANT

TO THE LARGEST DIMENSIONS AND CAPABILITIES

PATENT CUTTER SUCTION DREDGERS, PATENT DIPPER DREDGERS, BUCKET HOPPER DREDGERS, SUCTION HOPPER DREDGERS, HOPPER BARGES, PIPE LINES, FLOATING CRANES, etc.

NEW BUCKETS, LINKS, PINS, GEARING, etc., supplied for existing Dredgers.

FLEMING & FERGUSON, Ltd.,

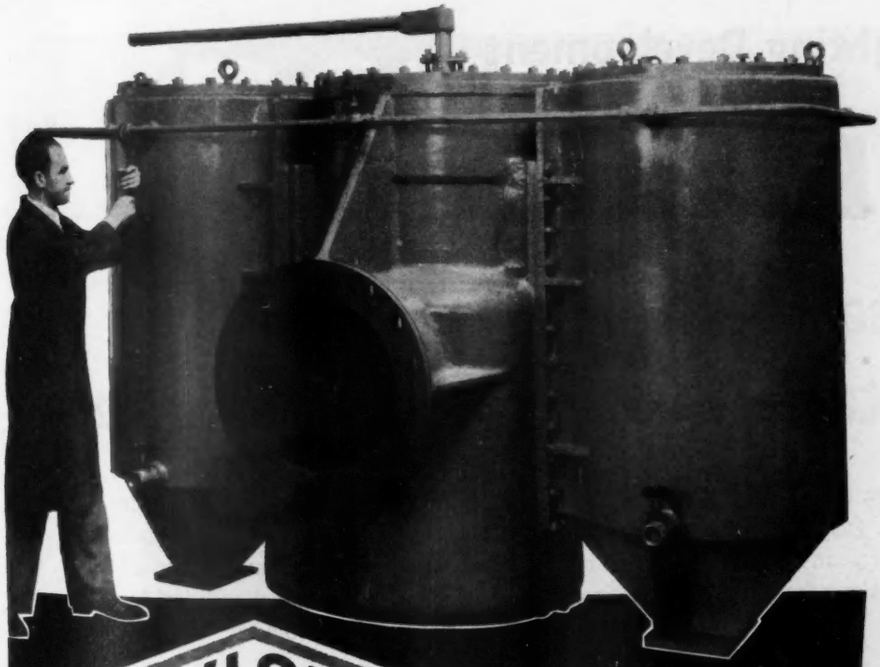
SHIPBUILDERS & ENGINEERS, PAISLEY, SCOTLAND,
Phone: Paisley 4121. *Teleg. Address: "Phenix, Paisley."*
London Agents: Messrs. Nye & Marks Ltd., Capel House, 42, New Broad Street, London, E.C.2.
Telephone: LONDON WALL 4846.

MANUFACTURERS OF
HEAVY IRON CASTINGS UP TO 20 TONS
STEEL FABRICATIONS FOR HEAVY ATOMIC PLANT
STAINLESS STEEL VESSELS COPPER COOLING COILS

M&W·GRAZEBROOK

LIMITED · EST. 1750
DUDLEY · WORCESTERSHIRE
TELEPHONE: DUDLEY 2431-3 · TELEGRAMS: GRAZEBROOK, DUDLEY

CLASS I PRESSURE VESSELS AND RAILWAY TANKERS
HOT PRESSINGS UP TO 14 INS. THICK, 11 FT. SQUARE
CHEMICAL PLANT HOMOGENEOUSLY LEAD LINED



The N.Z. DUAL FILTER

gives continuous flow of filtered liquid —
water, petrol, oils
Size range ½ in. to 20 in.

The filter illustrated is a 20 in. size recently supplied for dealing with river water; it handles 500,000 gallons per hour.

Some features:
FILTER CAGES CAN BE USED SINGLY OR IN PARALLEL · SPECIAL VALVE PERMITS CLEANING WITHOUT INTERRUPTING FLOW · MAY BE INSTALLED VERTICALLY OR HORIZONTALLY.

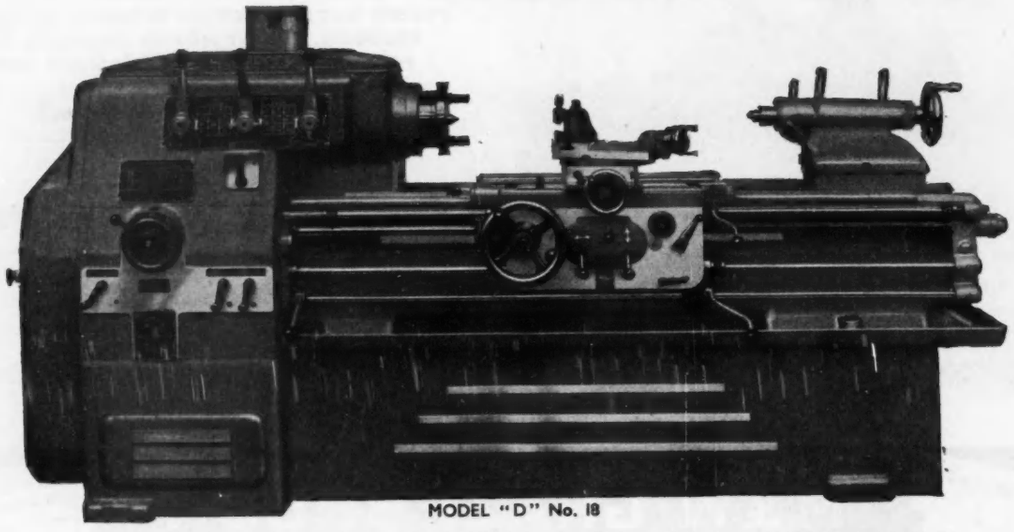
ZWICKY

ZWICKY LTD.

TRADING ESTATE, SLOUGH, BUCKS.
Telephone: SLOUGH 24481/3
Telegrams: "ZWIKLIM, SLOUGH"

positive filtration

STRATFORD **Holbrook** LONDON



MODEL "D" No. 18

PRECISION TOOL-ROOM LATHES

MODEL "D"

BUILT IN 3 SIZES SWINGING 13-15-18 INCHES OVER BEDWAYS

The Finest Lathe in its Class

We are exhibiting at the INTERNATIONAL MACHINE TOOL EXHIBITION, LONDON June 22 - July 6 GRAND HALL STAND No. 29

An important New Lighting Development

Mazda

Universal Lighting Trunking adapted to take 8′ Fluorescent Lamps

This means you can instal more flexible lighting than ever before. Mazda 8ft. (125-watt) tubes can now be mounted singly, in pairs, or mixed with 5ft. tubes anywhere along the trunking run.

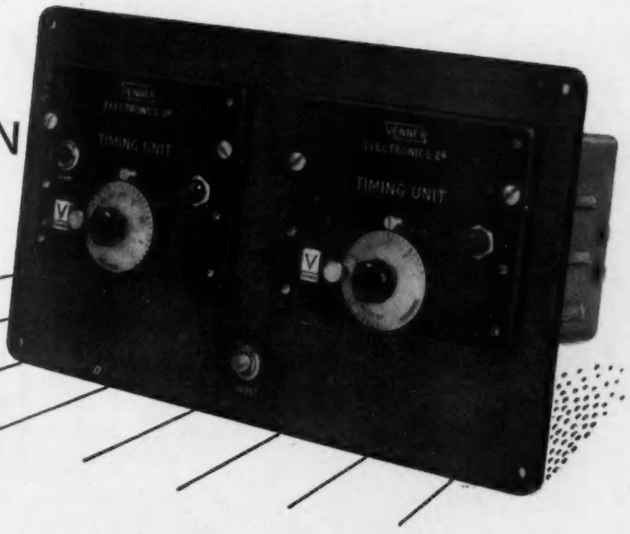
A new 8ft. open-ended reflector has been specially designed for use with either one or two 8ft. tubes. And because they are so economical to instal and operate you will find them ideal for large-scale industrial lighting projects.

Mazda lamps stay brighter longer

THE A.E.I. LAMP & LIGHTING COMPANY LTD. (*Member of the A.E.I, Group of Companies*)
CROWN HOUSE, ALDWYCH, LONDON, W.C.2. TEL: TEMPLE BAR 8040
Incorporating the lamp and lighting business of:
The British Thomson-Houston Co. Ltd.
The Edison Swan Electric Co. Ltd.
The Metropolitan-Vickers Electrical Co. Ltd.

M. 4640A

INCREASE PRODUCTION



WITH

VENNER

Multiple unit

ELECTRONIC PROCESS TIMERS

Venner Electronic Process Timers are now available in multiple unit form for sequence operation and can be supplied panel mounted from two up to any convenient number of units. The units can also be supplied on channel fitting for free standing wall mounting. For full details write for leaflet E101.

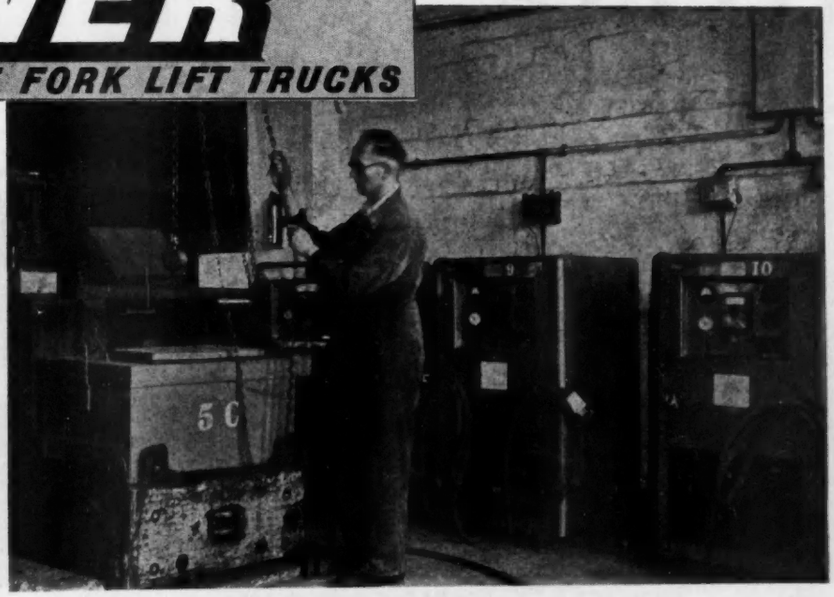
The Venner Electronic Timing unit is particularly suitable for sequence or cyclic timer operations involving several timing intervals in addition to individual process timer applications. Separate units measure 5in. by 4in. by 4in. Case finished in light grey stove enamel with front panel finished black crackle.

VENNER ELECTRONICS LIMITED

Kingston By-Pass, New Malden, Surrey. Telephone: MALden 2442 (9 lines)

Member of the Venner Group of Companies, Manufacturers of:-
Time Switches . Silver-Zinc Accumulators . Process Timers . Aircraft Instruments . Electronic and Electro-Mechanical Instruments . Park-O-Meters

THE POWER
BEHIND THE FORK LIFT TRUCKS

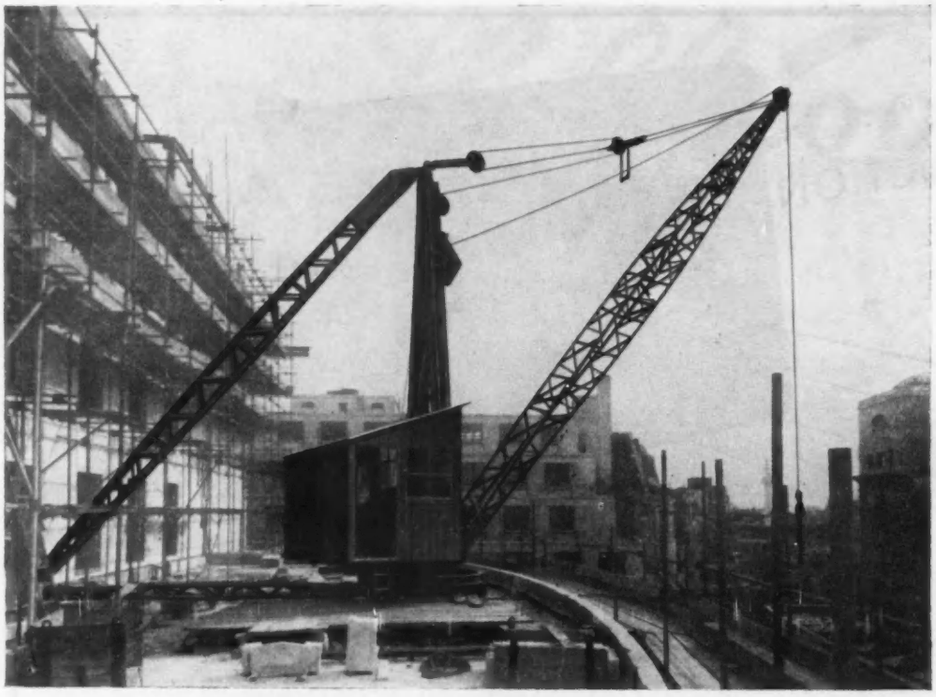


WESTALITE

DOUBLE VOLTAGE BATTERY CHARGERS

are installed in Messrs. Canon's Marsh Tobacco Bonds Ltd., Bristol, and are specially designed to meet arduous operating conditions where the Fork Lift Trucks need more than one battery per shift or working day. The sequence chargers will charge up to three lead-acid or four alkaline batteries per 24 hours, the change over from No. 1 to No. 2 battery, etc., and final shut down being completely automatic. Write for Data Sheet No. 831 containing full details of our battery chargers.

DEPT. ENG. R.G. 6. WESTINGHOUSE BRAKE & SIGNAL CO. LTD., 82, YORK WAY, KING'S CROSS, LONDON, N.1. Telephone: TERminus 6432



3-Ton Electric Derrick Crane x 60ft. Jib.

ELECTRIC DERRICK CRANES

also manufacturers of:
HAND and STEAM DERRICK CRANES and ELECTRIC OVERHEAD TRAVELLING CRANES

LONDON OFFICE: Finsbury Pavement House, 120 Moorgate, E.C.2.
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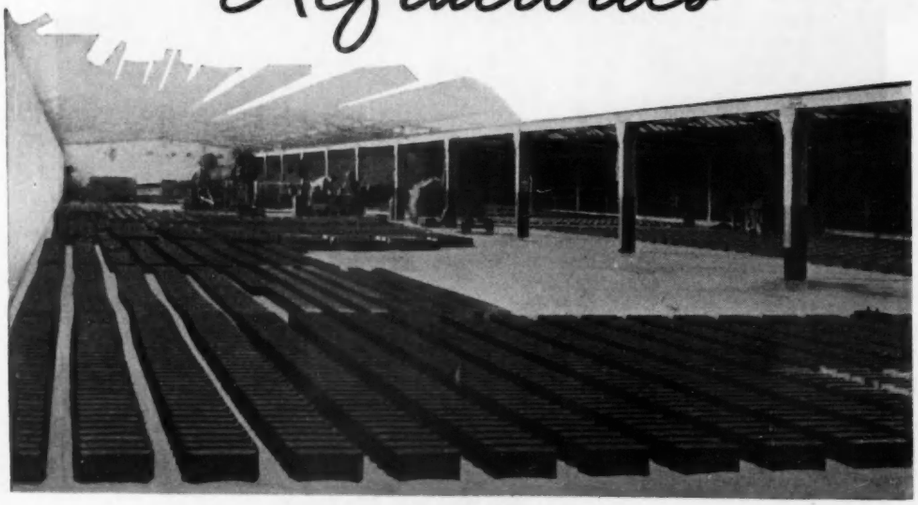
ANDERSON

THE ANDERSON-GRICE CO. LTD.
TAYMOUTH ENGINEERING WORKS, CARNOUSTIE, SCOTLAND

Telephone: CARNOUSTIE 2214/5 *Telegrams:* DIAMOND, CARNOUSTIE

STEIN *Refractories*



SPECIAL SHAPES IN FIREBRICKS

Careful making by experienced moulders allied with thorough firing in our kilns ensure uniformity of shape, size and texture in all our fireclay specials.

Qualities available:

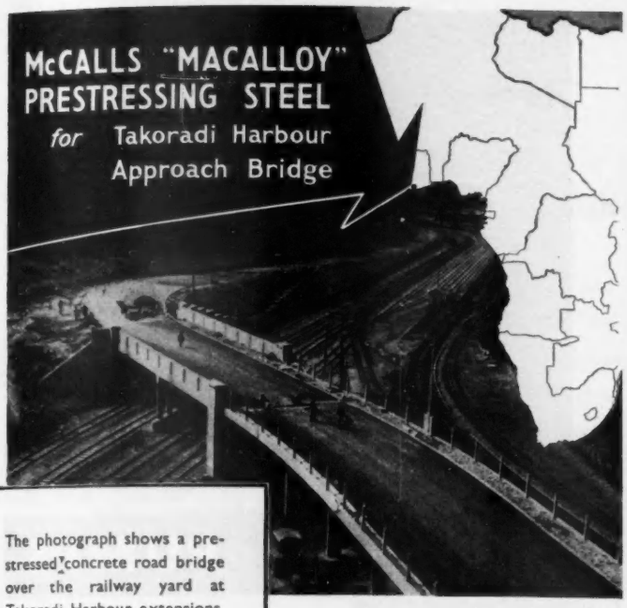
Nettle	42% Alumina,	Cone 34—1750°C
Thistle	35/37% ,,	Cone 31—1690°C
Stein	30/32% ,,	Cone 30—1670°C

Copies of our No. 1 Pamphlet, describing our complete range of Firebrick qualities, gladly sent on request

JOHN G. STEIN & Co LTD Bonnybridge, Scotland

TEL: BANKNOCK 255 (4 LINES)

McCALLS "MACALLOY" PRESTRESSING STEEL for Takoradi Harbour Approach Bridge

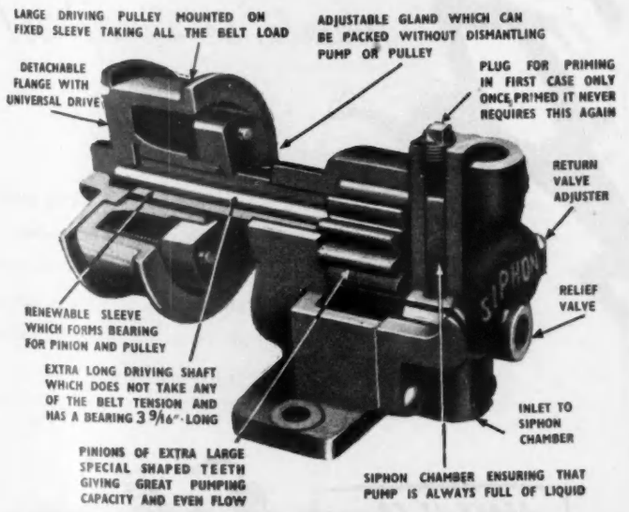


The photograph shows a prestressed concrete road bridge over the railway yard at Takoradi Harbour extensions, Gold Coast Colony. The precast beams of the bridge are of 44-ft. span, each post-tensioned with 3in. to 1¼in. diameter Macalloy bars.

Designed by Rendell, Palmer and Tritton, Consulting Engineers to Gold Coast Railways and Harbours Administration, and making use of the Lee-McCall system, the bridge was constructed by Taylor Woodrow (West Africa) Ltd.

McCALLS MACALLOY LIMITED
TEMPLEBOROUGH SHEFFIELD · P.O. BOX 41
Telephone: ROTHERHAM 2076 (B.P. EX 8 LINES) · LONDON OFFICE: 8-10 GROSVENOR GARDENS, S.W.1
also at Birmingham and Portsmouth. Telephone: SLOANE 0428
FC32

WE ARE DESIGNERS AND MANUFACTURERS OF THE
MODERN Siphon pump


LARGE DRIVING PULLEY MOUNTED ON FIXED SLEEVE TAKING ALL THE BELT LOAD
ADJUSTABLE GLAND WHICH CAN BE PACKED WITHOUT DISMANTLING PUMP OR PULLEY
DETACHABLE FLANGE WITH UNIVERSAL DRIVE
PLUG FOR PRIMING IN FIRST CASE ONLY ONCE PRIMED IT NEVER REQUIRES THIS AGAIN
RETURN VALVE ADJUSTER
RELIEF VALVE
RENEWABLE SLEEVE WHICH FORMS BEARING FOR PINION AND PULLEY
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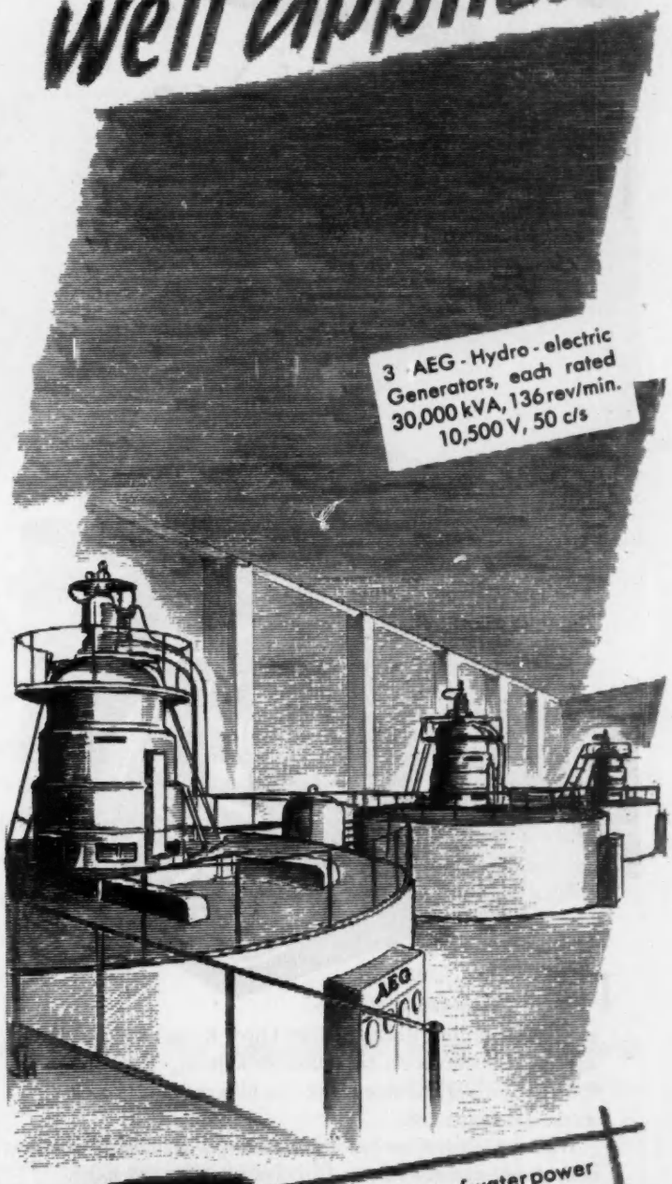
Water-Power well applied



AEG means ELECTRICITY

Economic utilization of water power for the generation of electric power has been a speciality of the AEG for over 60 years. The incorporation of improvements, resulting from extensive experience, as well as new ideas in the planning and construction of electrical equipment for Hydro-Electric Stations has gained for the AEG a leading role in this field.

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Warner may be able to take you a step nearer to automation — ask us.

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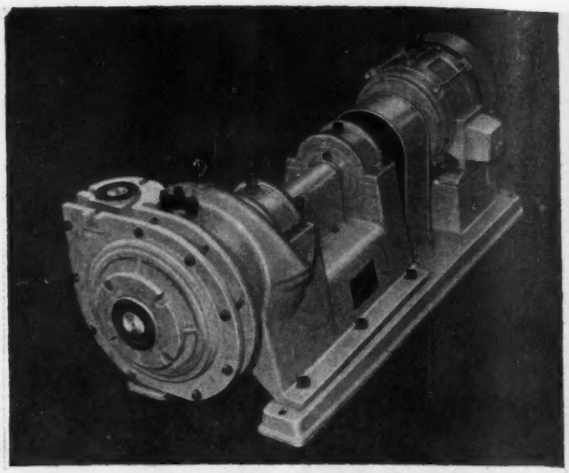

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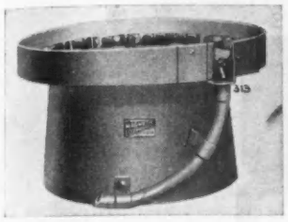

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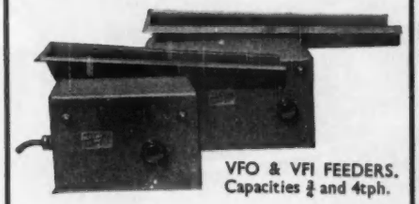

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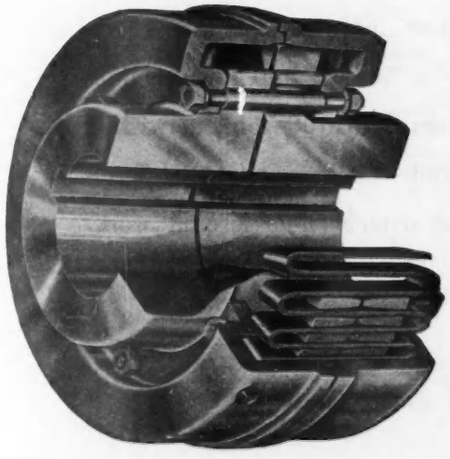

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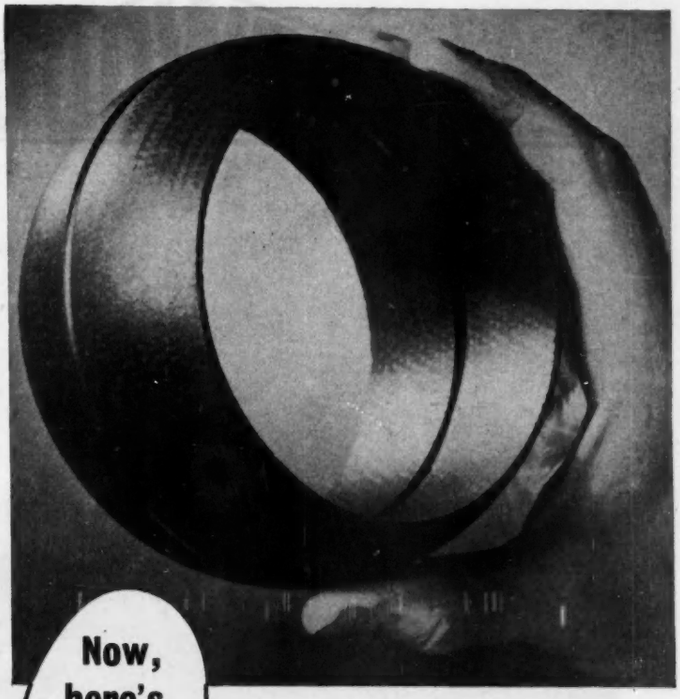

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it's an asbestos-based material—non-metallic, of course—impregnated with resins and moulded into a hard infusible substance. Ferobestos Plastics are not substitutes . . . they're engineering materials in their own right. Ferobestos plastics have many advantages which can be (and have been) put to use by engineers in many industries:—

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Here are just a few applications of the various grades of Ferobestos plastics:—

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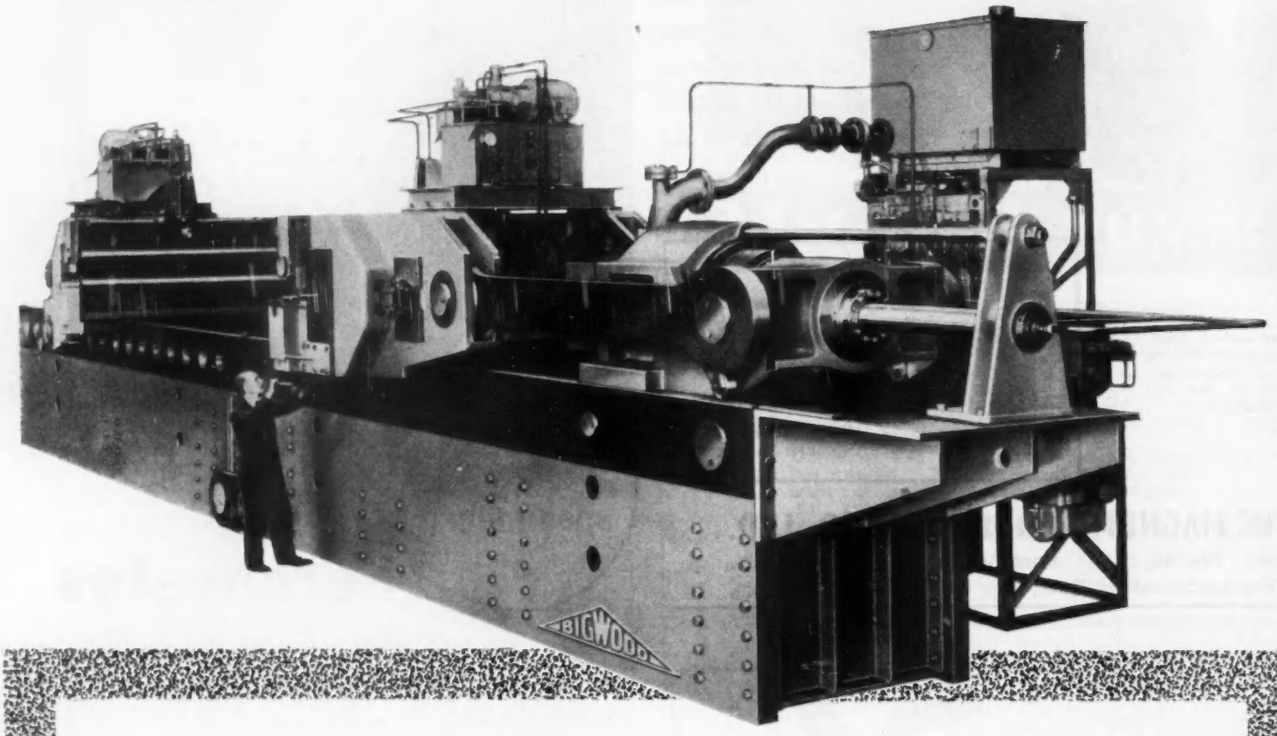

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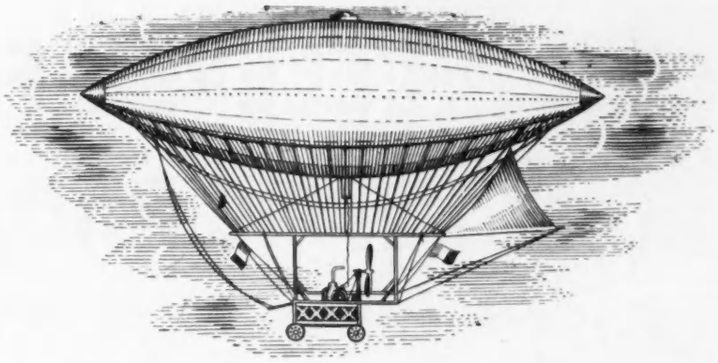

The span of a century has seen the development from the gas driven balloon to the Turbo-Jet. In this period also The Morgan Crucible Company has grown to a unique position; a position in which the products, parts and pieces they develop and manufacture are essential, either directly or indirectly, to every industry throughout the world. Their products may have helped the early aeronautical designers, certainly today's aircraft industry recognises the value of their aid—and the future will not ask in vain from the technologists and craftsmen who will use the knowledge and skill accumulated in these past 100 years.

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ATLAS COPCO EQUIPMENT AT WORK ON ELEVEN FRENCH HYDRO-ELECTRIC PROJECTS

MEETING POST-WAR DEMAND

In 1949, the combined installed generating capacity of French water power stations was 5.6 million kilowatts. To meet an ever-increasing industrial and domestic demand due to post-war reconstruction, *l'Electricité de France* launched a large-scale power development programme. This included the construction of more than eleven new hydro-electric plants to harness the mountain waters of the Pyrenées, the Alps and the Massif-Central region. The installed capacity now stands at 8.5 million Kilowatts. Atlas Copco equipment has been working on no less than eleven of the projects which have an installed water-power capacity totalling 1.5 million kilowatts, accounting for half the increase in capacity since 1949.

ATLAS COPCO CHOSEN AGAIN

The construction of the hydro-electric projects meant engineering on a grand scale, calling for extensive excavating and tunnelling operations. Vast quantities of Atlas Copco light rock drills and Sandvik Coromant steels were supplied by the Atlas Copco company in France, Atlas Copco France, S.A., to carry out much of this work.

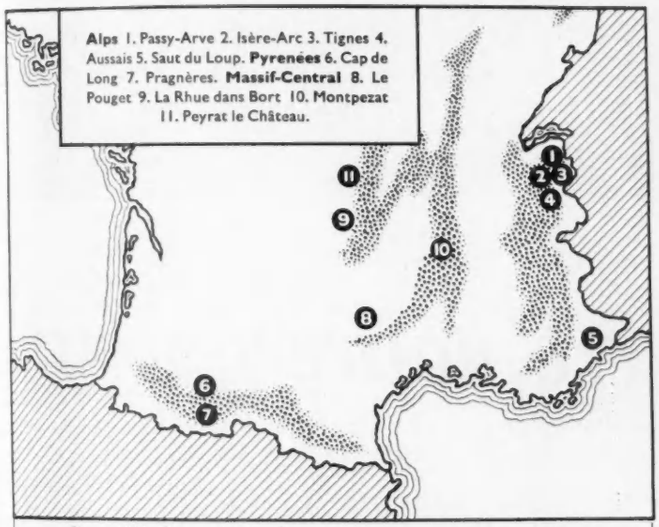
UNBEATABLE DRILLING COMBINATION

On hydro-electric projects from Brazil to Norway, Australia to Canada, Atlas Copco drills and Sandvik Coromant steels are in operation. These drills and steels were developed to work together as a lightweight drilling unit. Since its introduction it has extensively replaced the heavier-rigged

drifter. Today, Atlas Copco drills and Sandvik Coromant steels are the world's most widely-used pusher leg drills and drill steels.

NEW SPEEDS AT LOWER COST

Atlas Copco light rock drills are compact, *one-man* machines. That enables you to put *more* drills into action at the face at one and the same time. More drills mean *faster* times each round and, because they are one-man machines, a reduction —in most cases—of total shift crews by at least a third. At the same time, the original capital outlay and general maintenance costs are far lower than for those of heavy equipment. So, if you want to do the job faster, and at lower cost, the Atlas Copco light rock drill is *your* machine.



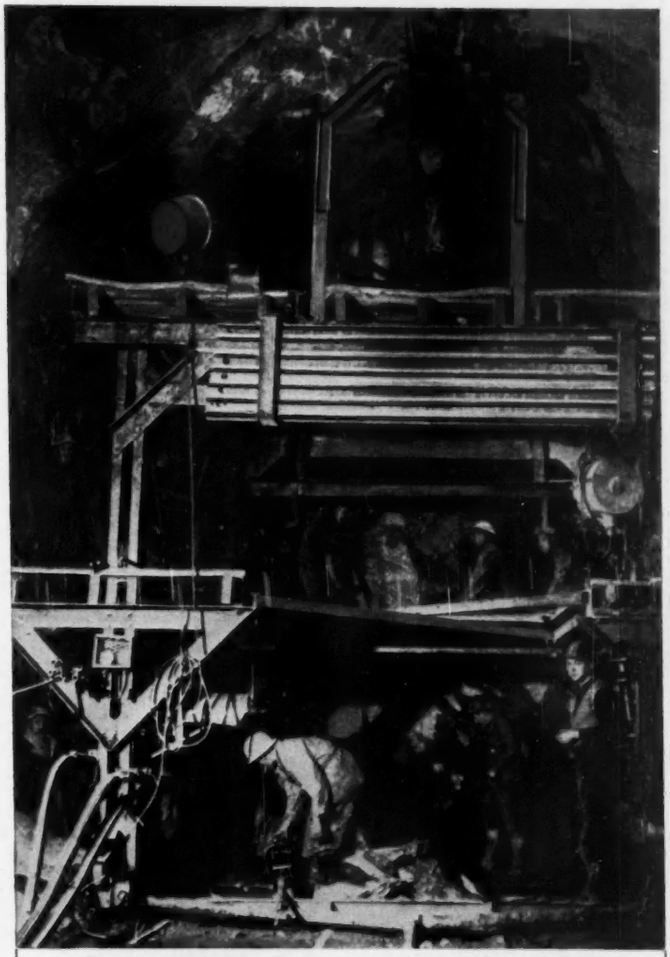
Since 1949, France has built many new power stations, including eleven hydro-electric projects indicated here. Atlas Copco drills and Coromant steels have been in operation on these projects.

COROMANT STEELS ARE EXTRA-TOUGH

At the drilling end of Atlas Copco rock drills you'll find Sandvik Coromant steels. With their extra-tough tungsten-carbide inserts, Sandvik Coromant steels show little or no loss of speed as they advance.

Sandvik, to maintain a never-varying drill steel quality, control every phase of production—from the mining of iron ore, processing of wolfram ore, to the final tungsten-carbide inserts used throughout the world wherever Atlas Copco drills are in action.

The Atlas Copco Group puts compressed air to work for the world. It embraces thirty-one Atlas Copco companies and twenty-four agents, manufacturing or selling and servicing Atlas Copco equipment in more than 50 countries throughout the world.



Tunnelling on the Isère-Arc project on which Atlas Copco one-man drills fitted with Sandvik Coromant tungsten-carbide tipped steels were used. The mobile drilling platform was developed by the Project Department of Atlas Copco.

For further details about Atlas Copco Drills and Sandvik Coromant Steels write to the most convenient of the addresses given here:

UNITED KINGDOM, Atlas Copco (Great Britain) Ltd., Wembley, Middx.; FRANCE, Atlas Copco France S.A., 29, Rue Marbeuf, Paris 8e; HOLLAND, Atlas Copco Holland N.V., P.O. Box 6056, Rotterdam; ITALY, Atlas Copco Italia S.p.A., Viale Marche 15, Milan.

CANADA, Atlas Copco Canada Ltd., Montreal, A.M.F., P.Q.; AUSTRALIA, Atlas Copco Australia Ltd., P.O. Box 54, Auburn, N.S.W.; SOUTH AFRICA, Delfos & Atlas Copco (Pty.) Ltd., P.O. Box 504, Benoni, Transvaal; U.S.A., Atlas Copco Pacific, Inc., 930 Brittan Avenue, San Carlos, California; Atlas Copco Eastern, Inc., P.O. Box 2568, Paterson 2, N.J.

Readers in countries outside those listed above and who do not know the name of their local Atlas Copco company or agent, please write to Atlas Copco AB, Stockholm 1, Sweden.

The services of the Project Department of Atlas Copco, whose job is to draw up drilling patterns and to advise on tunnelling and mining techniques, is at the disposal of contractors everywhere without obligation.

Manufacturers of Stationary and Portable Compressors, Rock Drilling Equipment, Loaders, Pneumatic Tools and Paint-Spraying Equipment.

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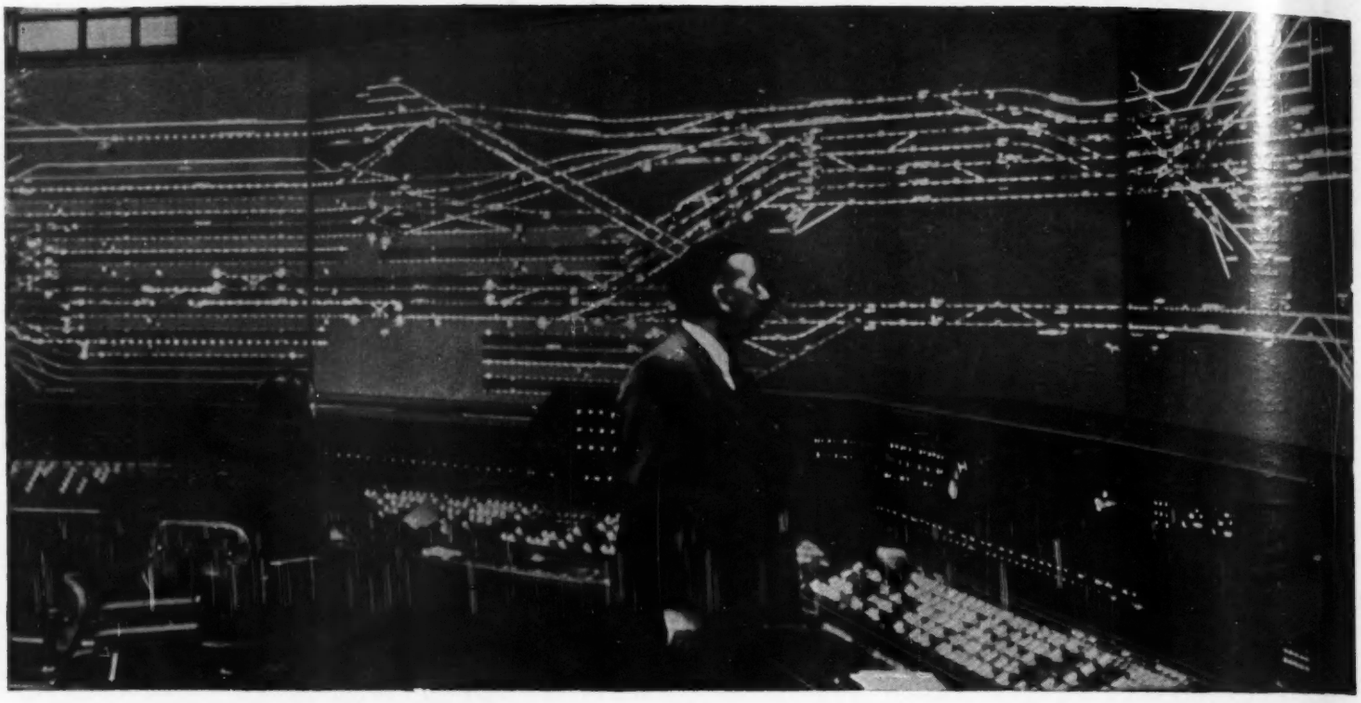

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If you have a communication problem write to BICC about it. Our engineers will design the cable and, if you wish, install it anywhere in the World.

* *Main contractors: Westinghouse Brake & Signal Co. Ltd.*

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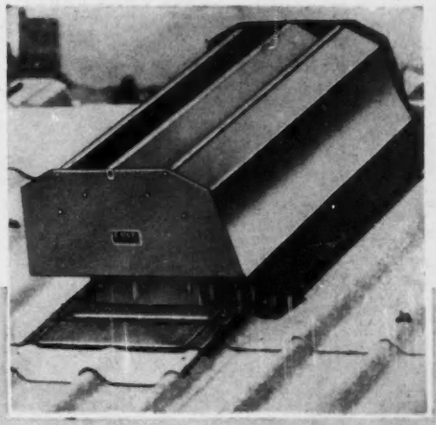
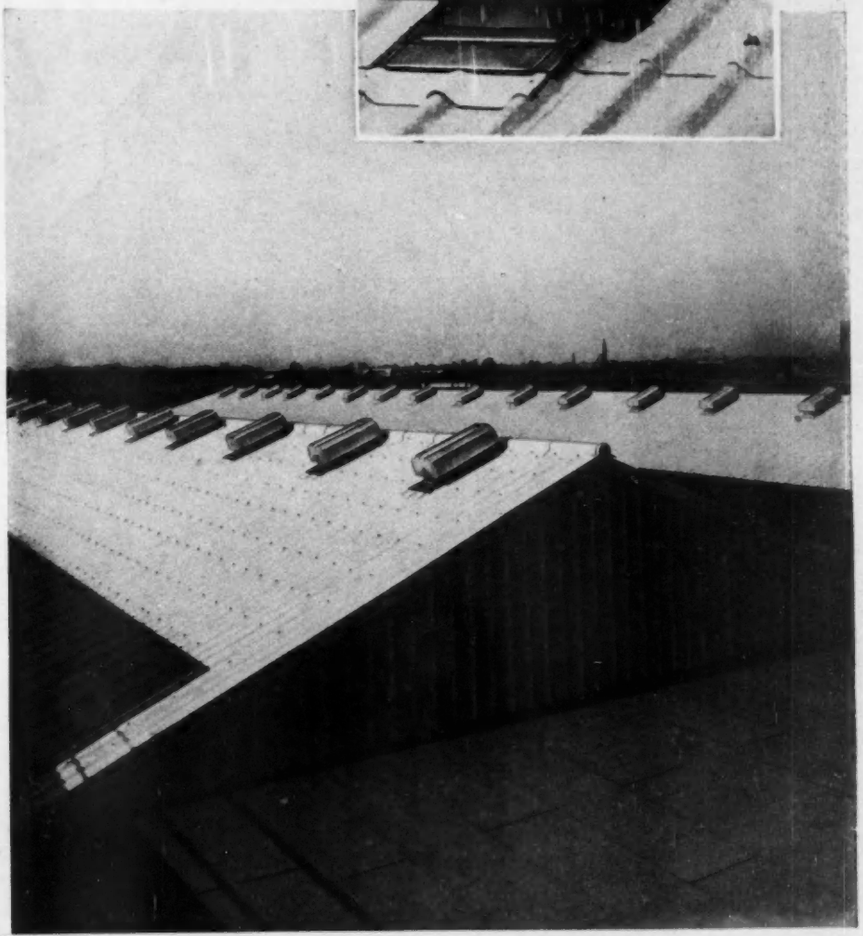
ARCHITECT: HARRY W. WEEDON, F.R.I.B.A. & PARTNERS



For the New Spares Stores for A.E.C. Ltd., the Architect required a natural system of ventilation to extract 3,000,000 cubic feet of air per hour from the building when desired. Control to facilitate the reduction of this rate of ventilation was also essential. Colt were consulted and a scheme involving the installation of 32 SRC/2046 Gear Controlled Ventilators was formulated and subsequently incorporated in the design of the building.

Of robust construction, and yet remarkably light, this High Duty Natural Roof Extractor incorporates aerofoil curves which harness the wind and roof eddies to combine with the power of convection within the building. It is maintenance free, and simple to install. One very notable feature is its appearance! When fixed in the roof it is quite unobtrusive.

Colt's wide experience in ventilating all types of buildings throughout industry is at your disposal. Whether the ventilation problem is large or small—in an existing building or for one still 'on the drawing board'—consult them first.



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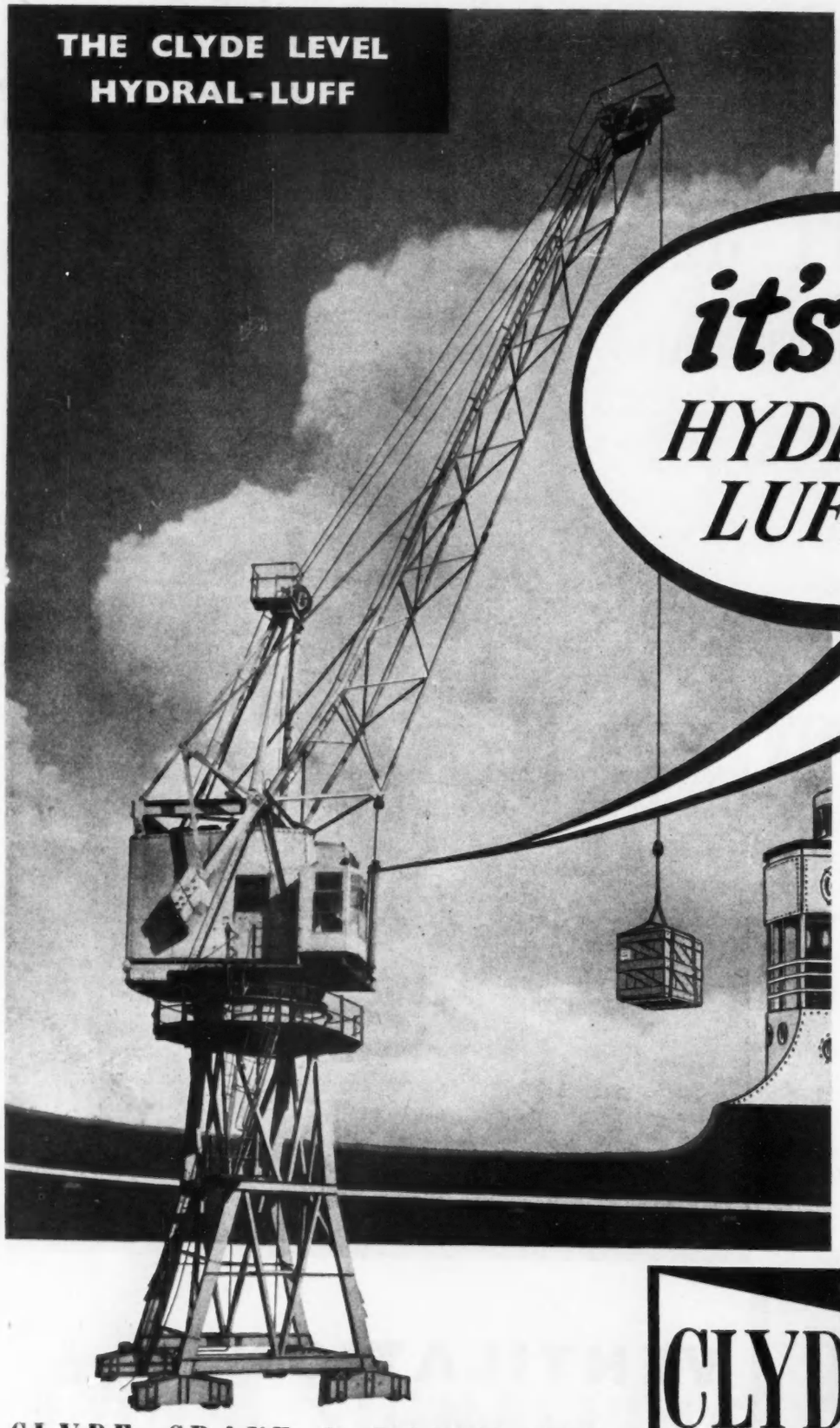
THE CLYDE LEVEL
HYDRAL-LUFF



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HYDRAULIC LUFFING!

. . . . . in the latest and most up-to-date high speed cargo handling crane in the world.

The Clyde L.H.L. is essentially an electric crane but uses hydraulic fluid as a transmission medium for operating the jib.

The illustration pin-points the hydraulic luffing ram which is controlled by a compact electro-hydraulic unit in the machinery house. This system reduces the number of moving parts, takes up less room and is remarkable for its smoothness and speed of action; it is in fact the modern solution to the problem of operating a high speed luffing motion.

May we furnish you with a general specification or arrange a demonstration.

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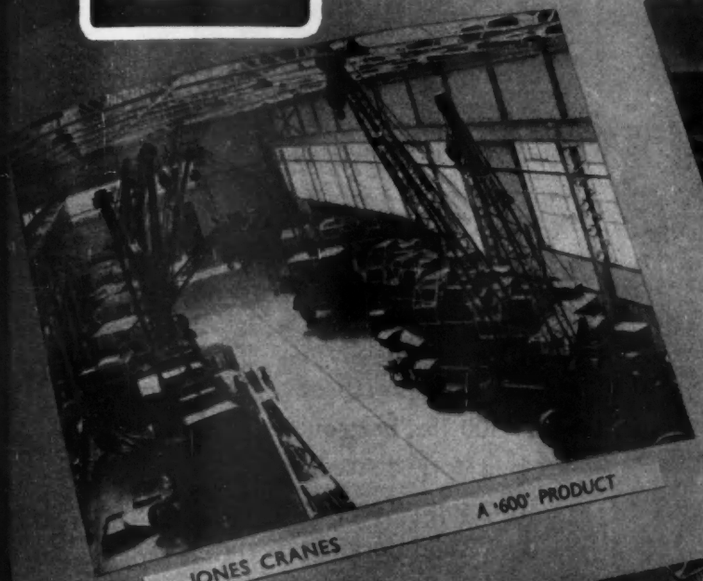

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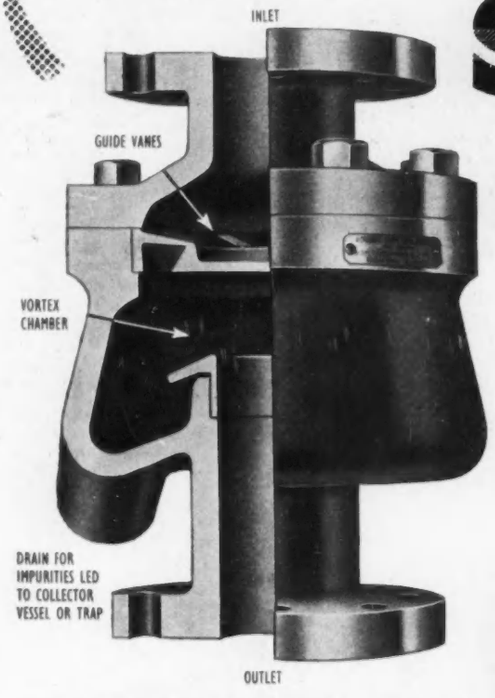
SUPREME VORTEX SEPARATORS

ALEXANDER'S PATENT

for the purification of Steam, Air or Gas



Supreme Vortex separators are supplied in cast-iron for pressures up to 150 lbs. per square inch and in cast-steel or gunmetal for higher pressures. For pressures above 500 lbs. per square inch special designs in forged steel can be supplied, the separator parts being machined from solid forgings. The shape of the body of the separator is admirably suited to withstand high pressures without employing objectionable strengthening webs which localise stresses and make stress values uncertain.

The extraction of impurities at all rates of flow is over 99% of any liquid or solid particles down to 1/250 inch diameter and a high percentage of even finer particles, providing the liquid solid content at entry does NOT exceed 15%. The separators are entirely self clearing even when the solid portion of the impurities is as much as 20% of the liquid portion. Because of the streamline flow and the complete absence of obstructions in the separating chamber, the pressure drop in vortex separators is at a minimum as compared with other separators of equal bulk and dealing with equal flow.

The separators can be fitted in all pressure pipes arranged for horizontal flow or downward vertical or inclined flow and conveying steam, gas or air in which there are suspended liquid or solid impurities such as water, oil, grit or scale. They are also useful for refrigeration, in the separation of the liquid phase from the gaseous phase of the working fluid used.

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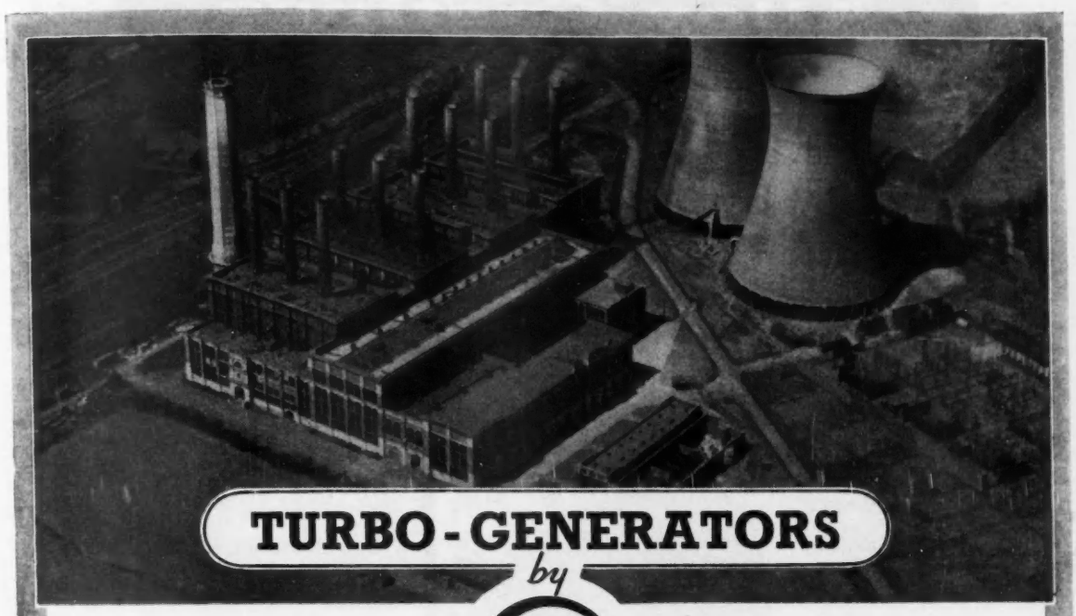

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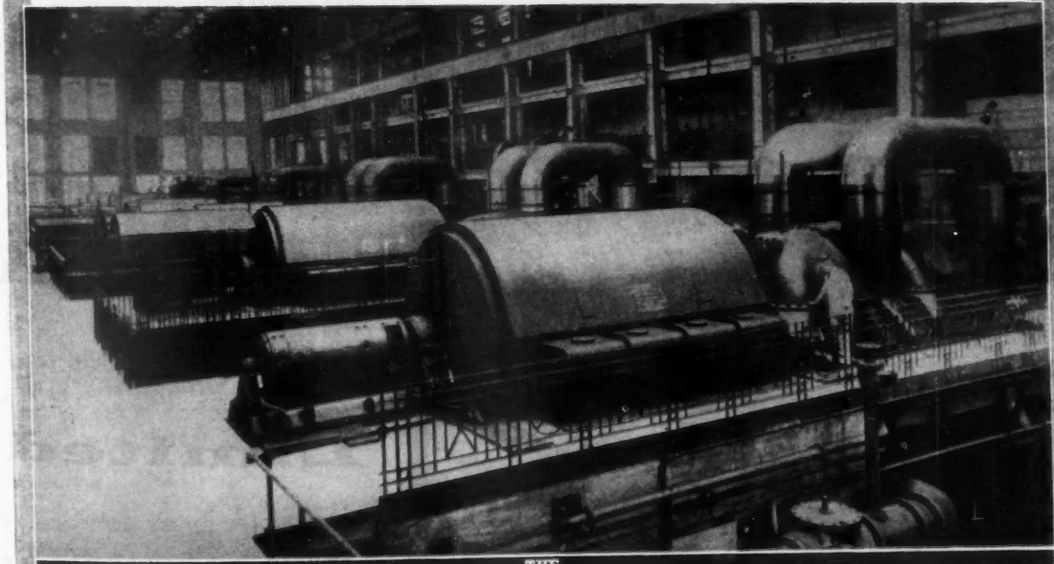
Power stations throughout the world are equipped with steam turbines and generators made by BTH, who hold a leading position as designers and manufacturers of some of the largest machines installed — or building. At the Kirkstall Station of the Central Electricity Authority, seven BTH turbo-alternators, ranging in size from 25,000 kW. to 30,000 kW., are providing a generating capacity of 200,000 kW.



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Member of the AEI group of companies

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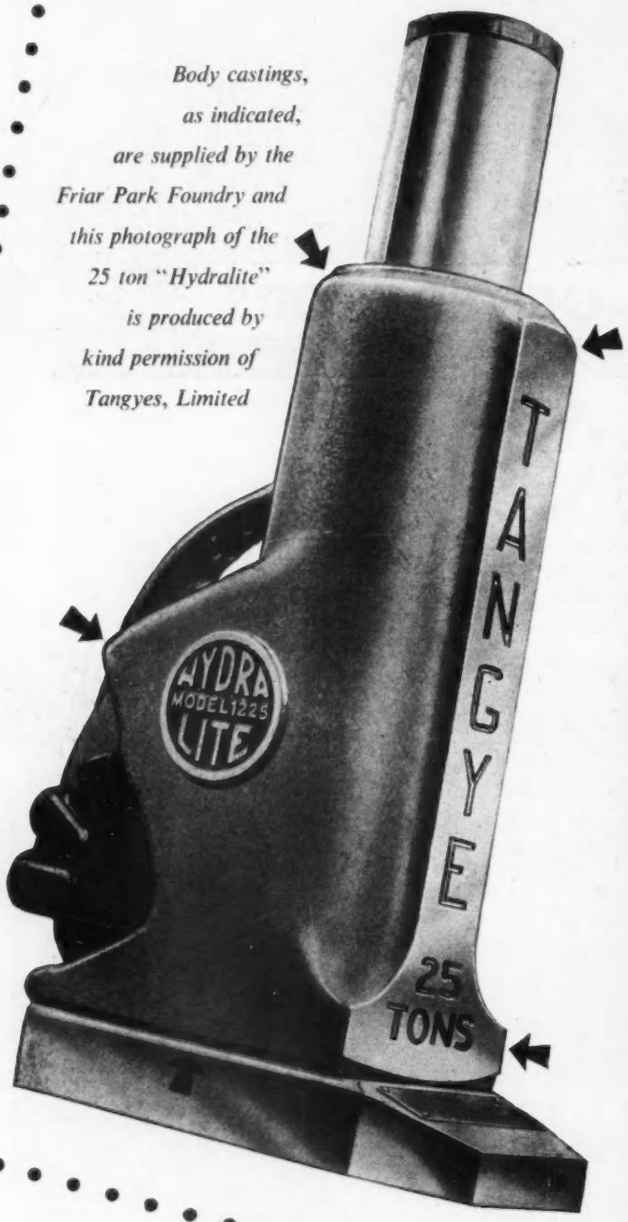
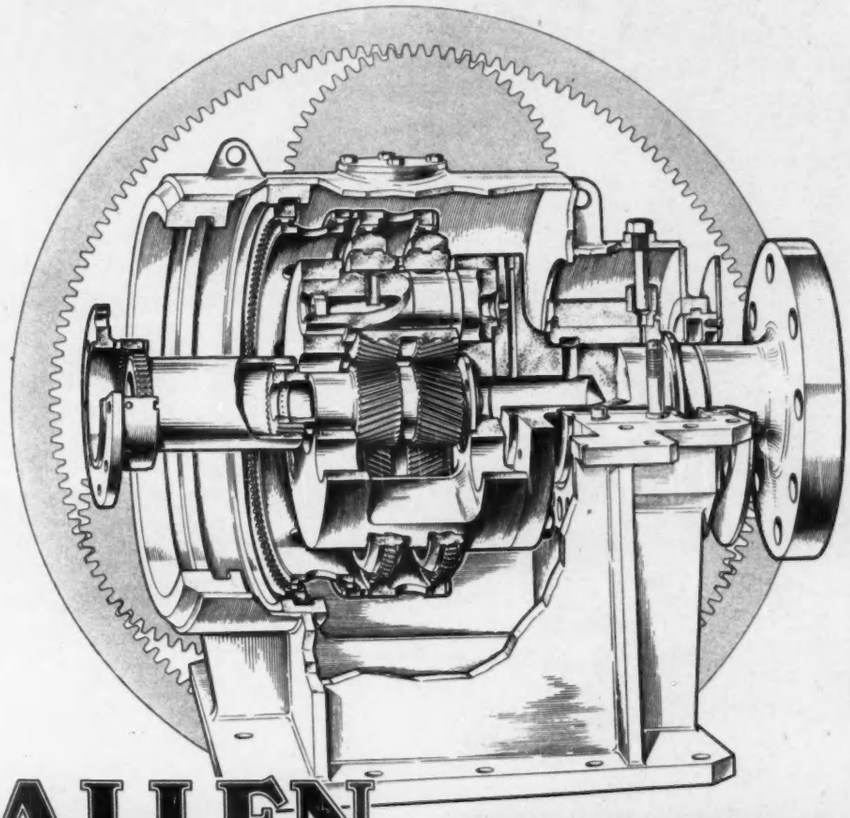


Body castings, as indicated, are supplied by the Friar Park Foundry and this photograph of the 25 ton "Hydralite" is produced by kind permission of Tangyes, Limited

By well considered designing and careful choice of modern materials, Tangyes, Ltd. of Birmingham have produced the "Hydralite" range of light-weight jacks. Produced mainly from aluminium alloys, with no sacrifice of the safety margin, they will lift 15 to 50 tons and yet themselves are lifted by one hand. This 25 ton Jack weighs only 53 lbs.

by William Mills Limited

FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.



ALLEN - STOECKICHT

PATENTED DOUBLE-HELICAL EPICYCLIC GEARING

IS FITTED IN THE

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The 1,000-kW RUSTON 'TA' gas turbine incorporates an ALLEN-STOECKICHT double-helical epicyclic gear as an integral part of the power turbine mounting. The gear is situated between the two exhaust ducts and, being built-in, provides a most compact arrangement. The output shaft of the gear also being in line with the remainder of the turbine, reduces the space occupied by the complete gas-turbine unit to a minimum.

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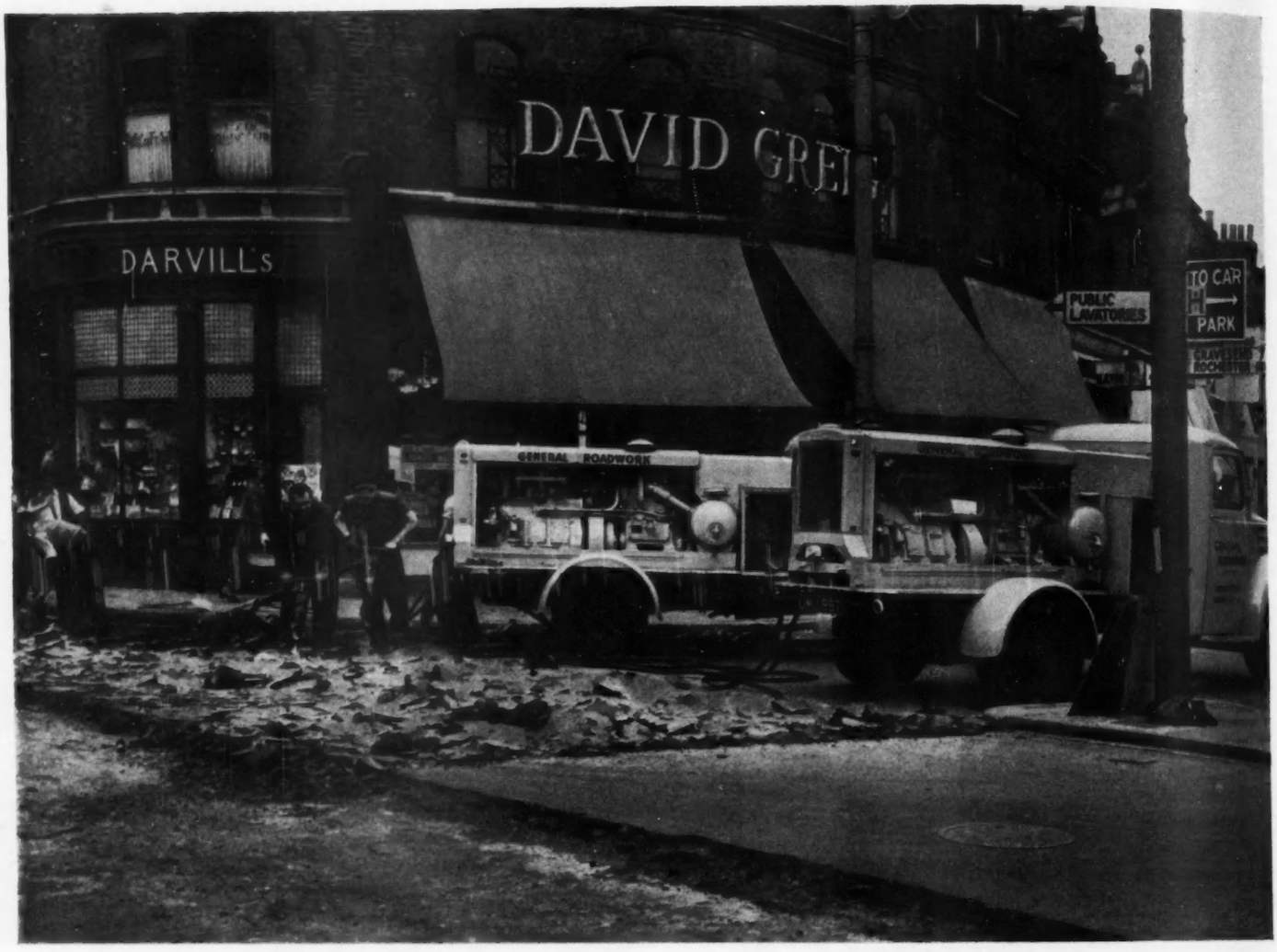

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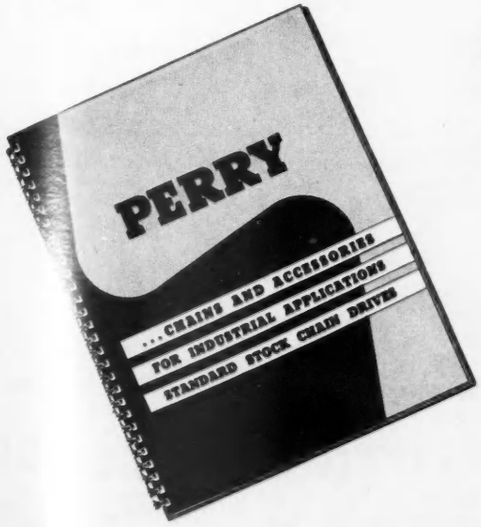

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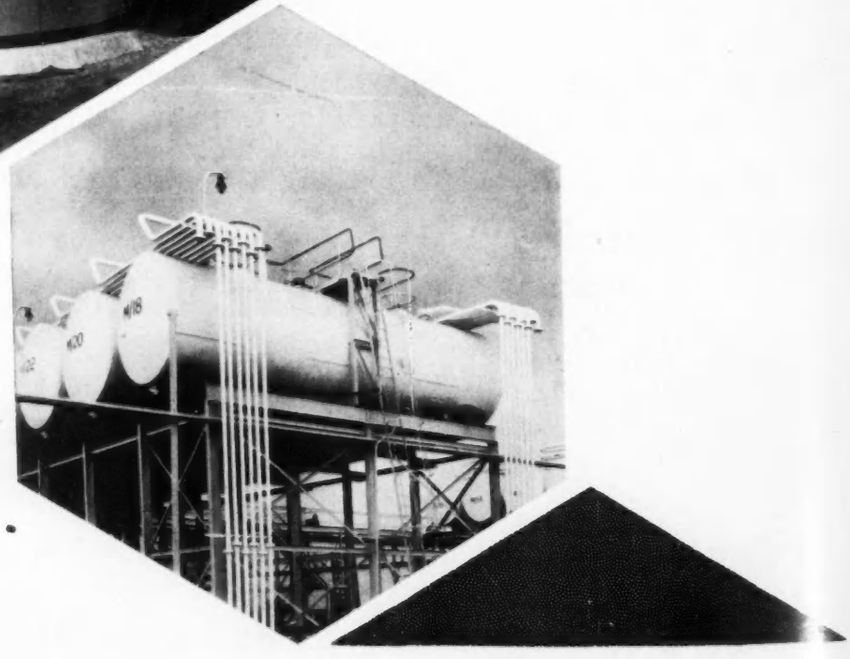

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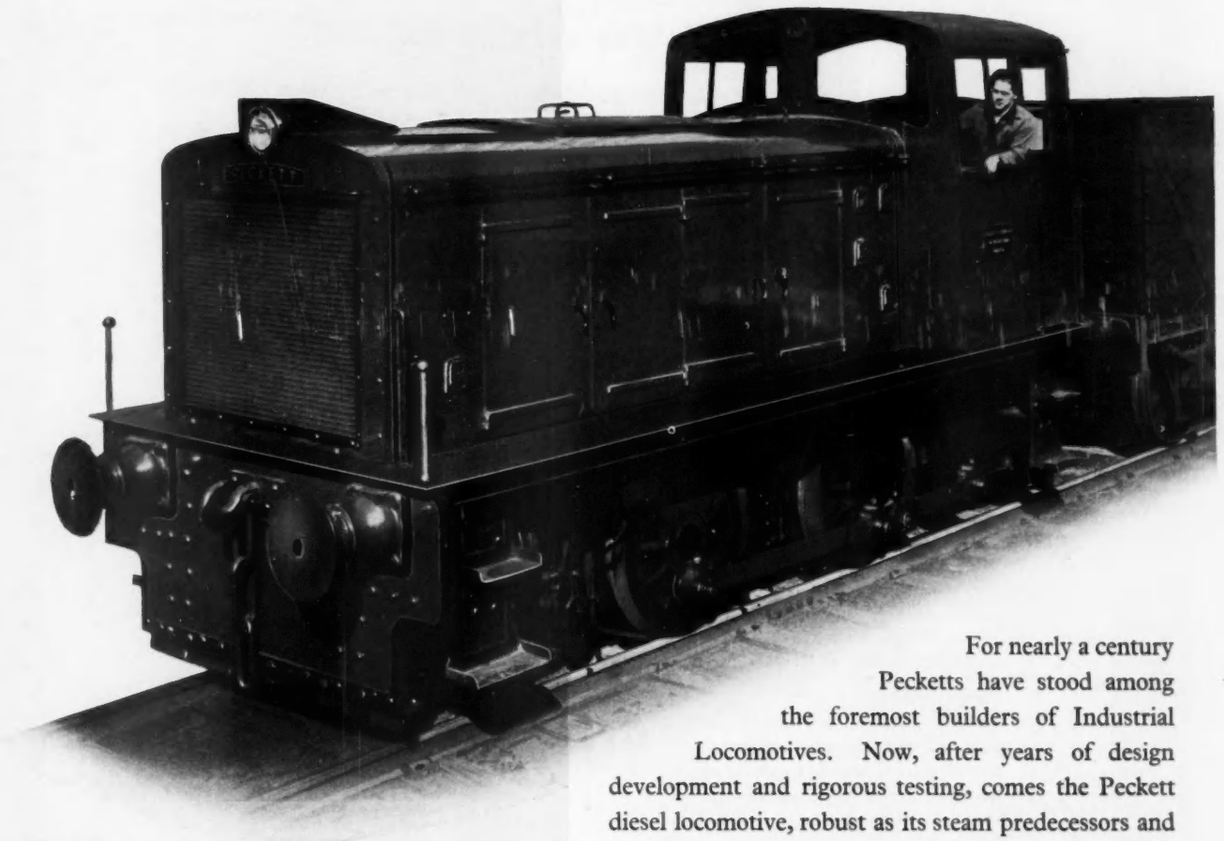

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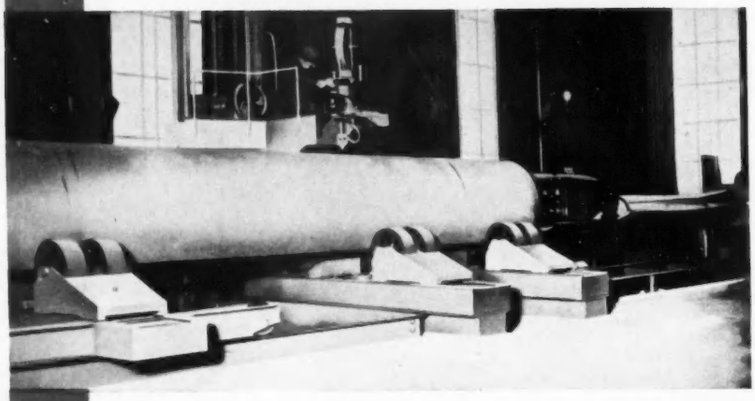

External and internal welding of Class 1 boiler drums, by the Fusarc process. Note the versatile cantilever—supported automatic welding head; boom-type internal welder (right) with effective welding traverse of 15′ 0″; and the adjustable motorised roller bed, working in conjunction with an idler-bed unit. All manufactured, installed and serviced by Quasi-Arc Limited—and only one of many complex automatic welding installations now in production.

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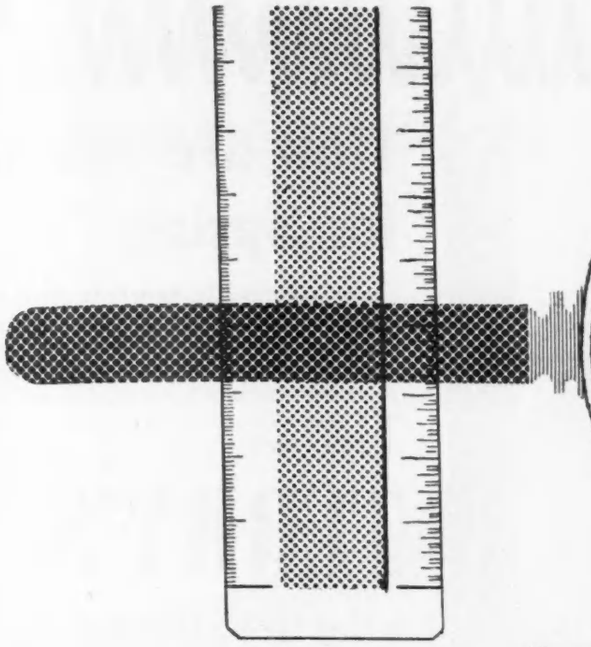

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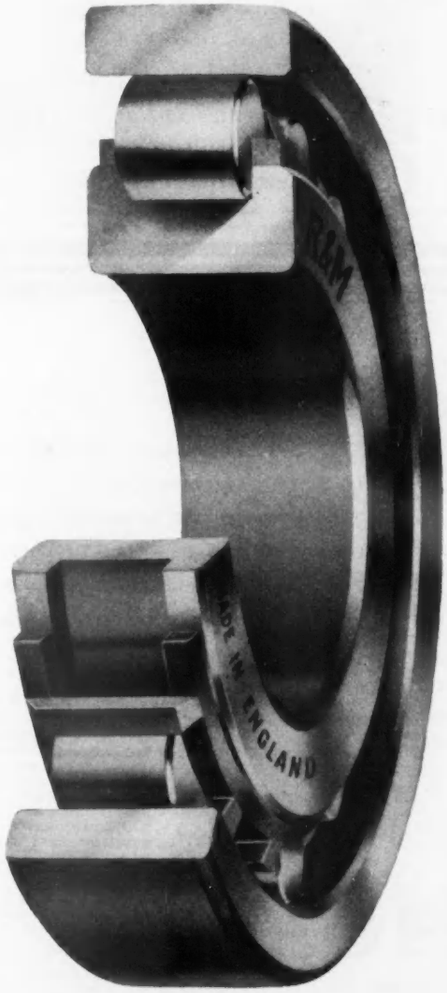

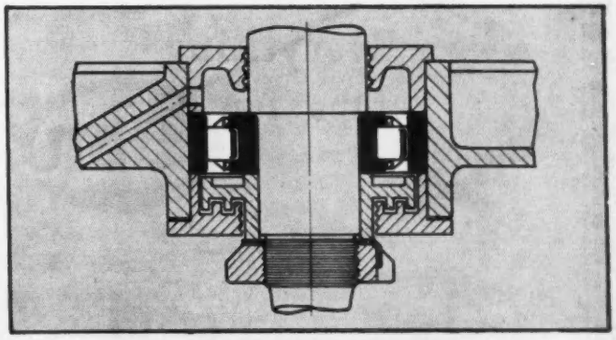

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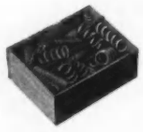

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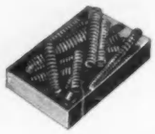

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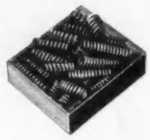

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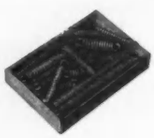

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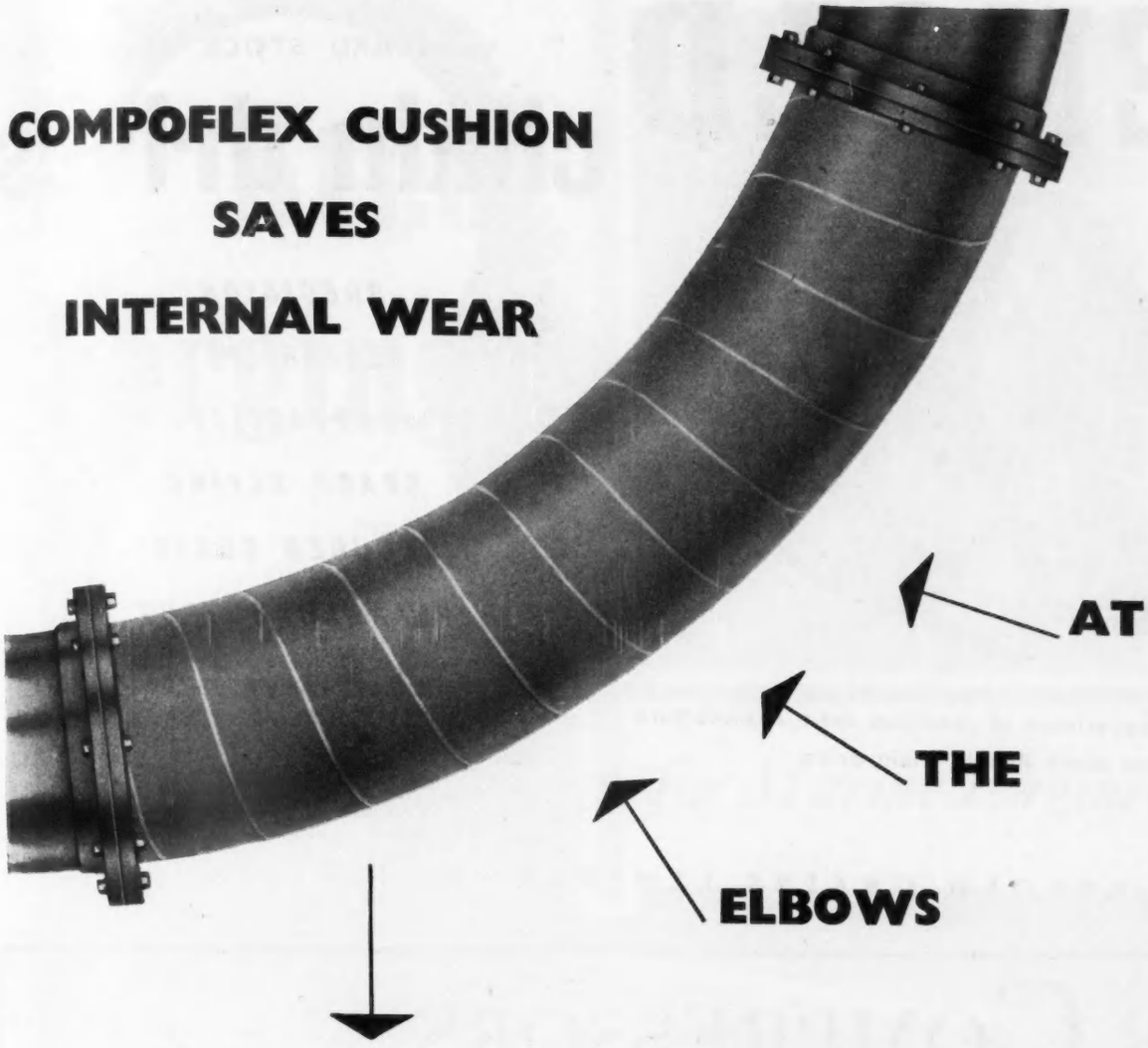

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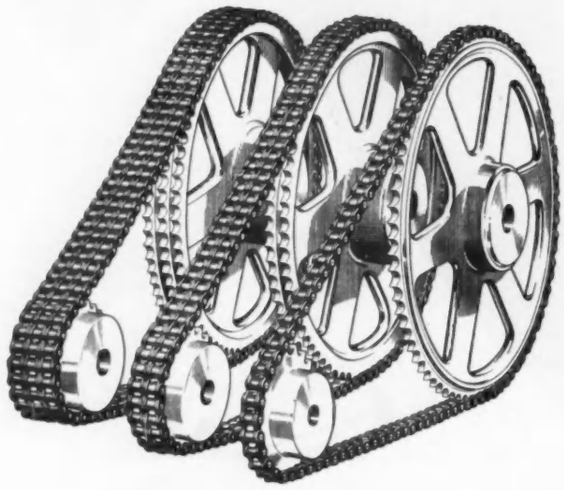

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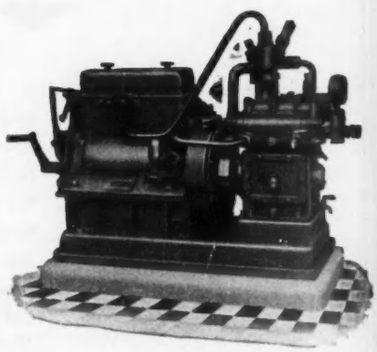

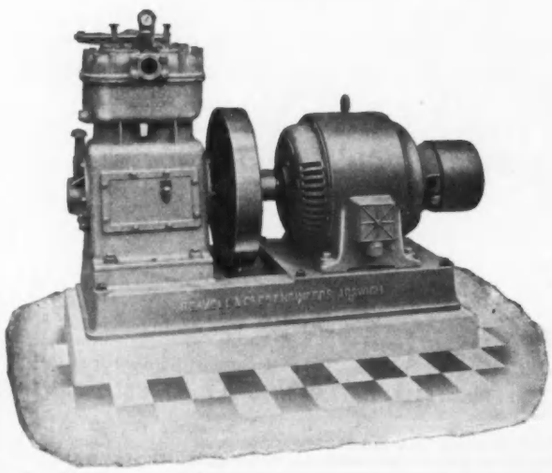

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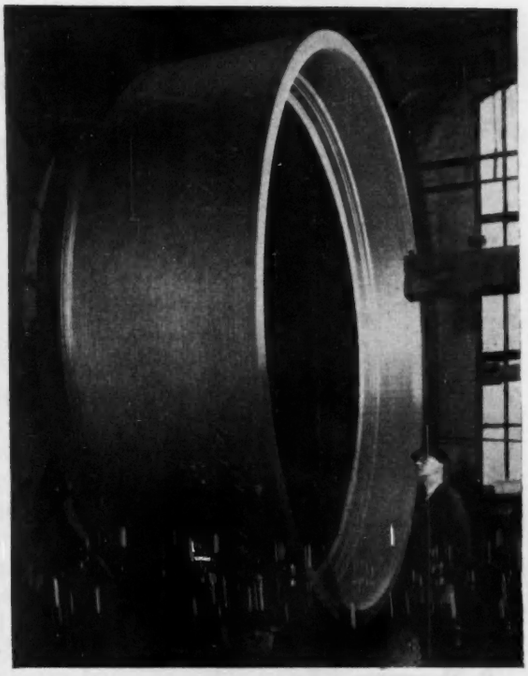

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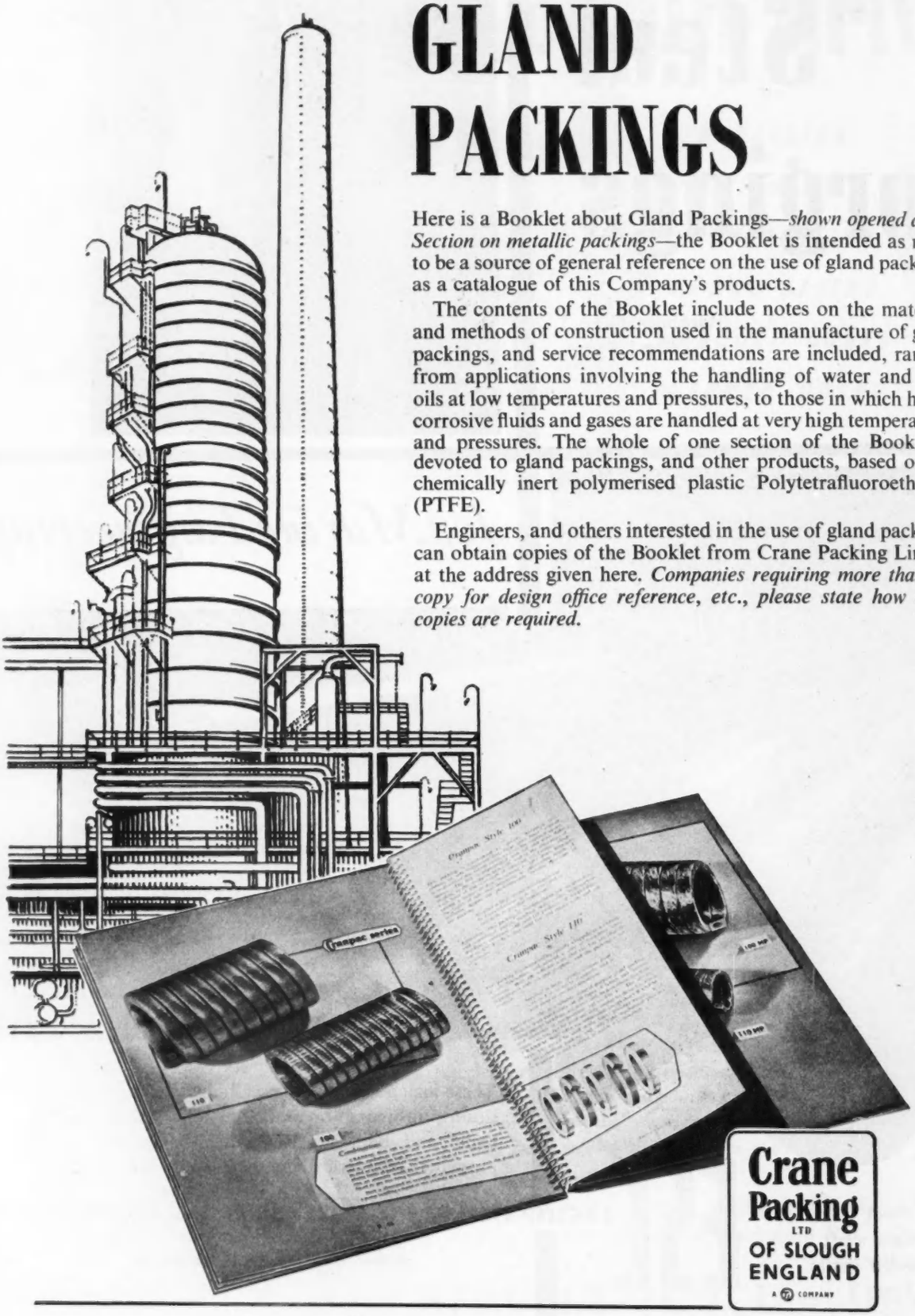
Engineers, and others interested in the use of gland packings, can obtain copies of the Booklet from Crane Packing Limited at the address given here. *Companies requiring more than one copy for design office reference, etc., please state how many copies are required.*



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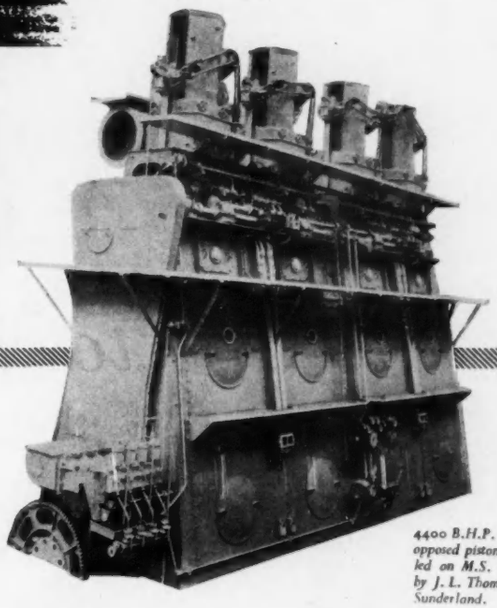
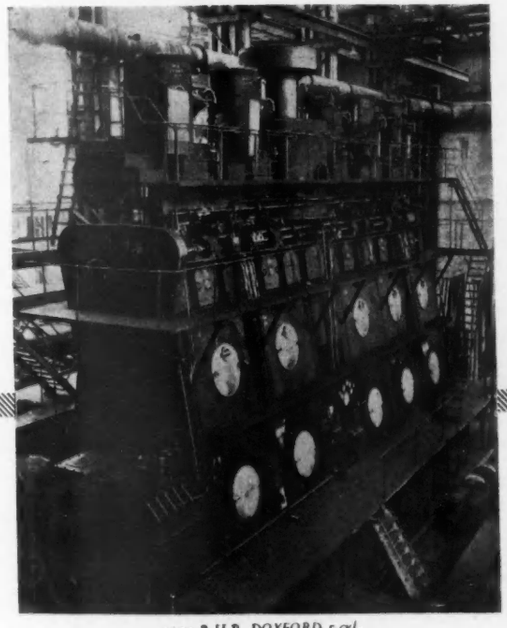


4400 B.H.P. DOXFORD 4 cyl. opposed piston oil engine, installed on M.S. Thistledown, built by J. L. Thompson & Sons Ltd., Sunderland.



5150 B.H.P. DOXFORD 5 cyl. opposed piston oil engine, as installed in four sister ships built by William Doxford & Sons Ltd. Sunderland.

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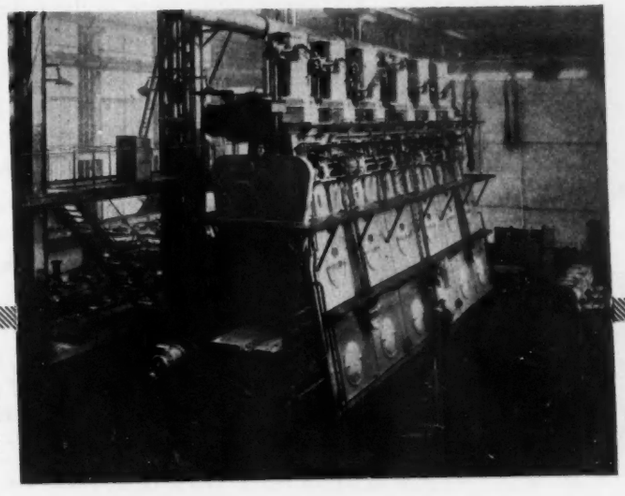

6400 B.H.P. DOXFORD 6 cyl. opposed piston oil engine, installed on M.S. British Reliance, built by Sir Jas. Laing and Sons Ltd., Sunderland.

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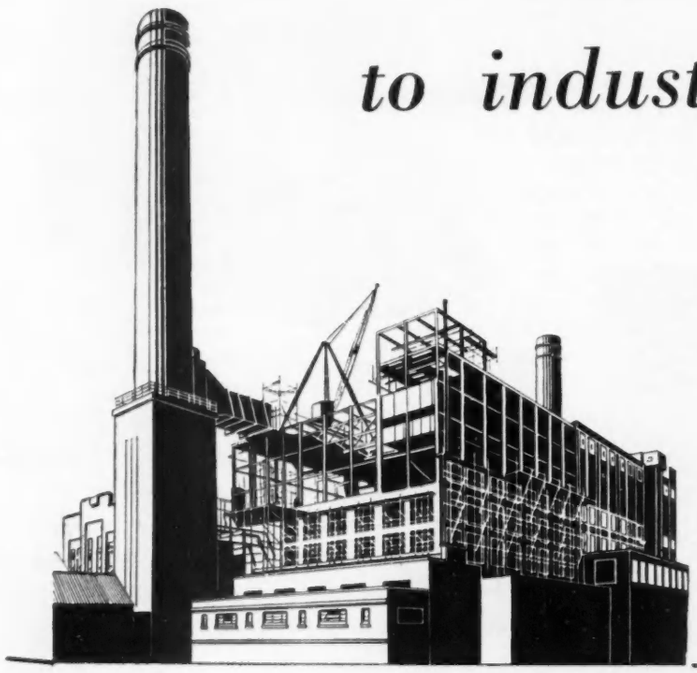

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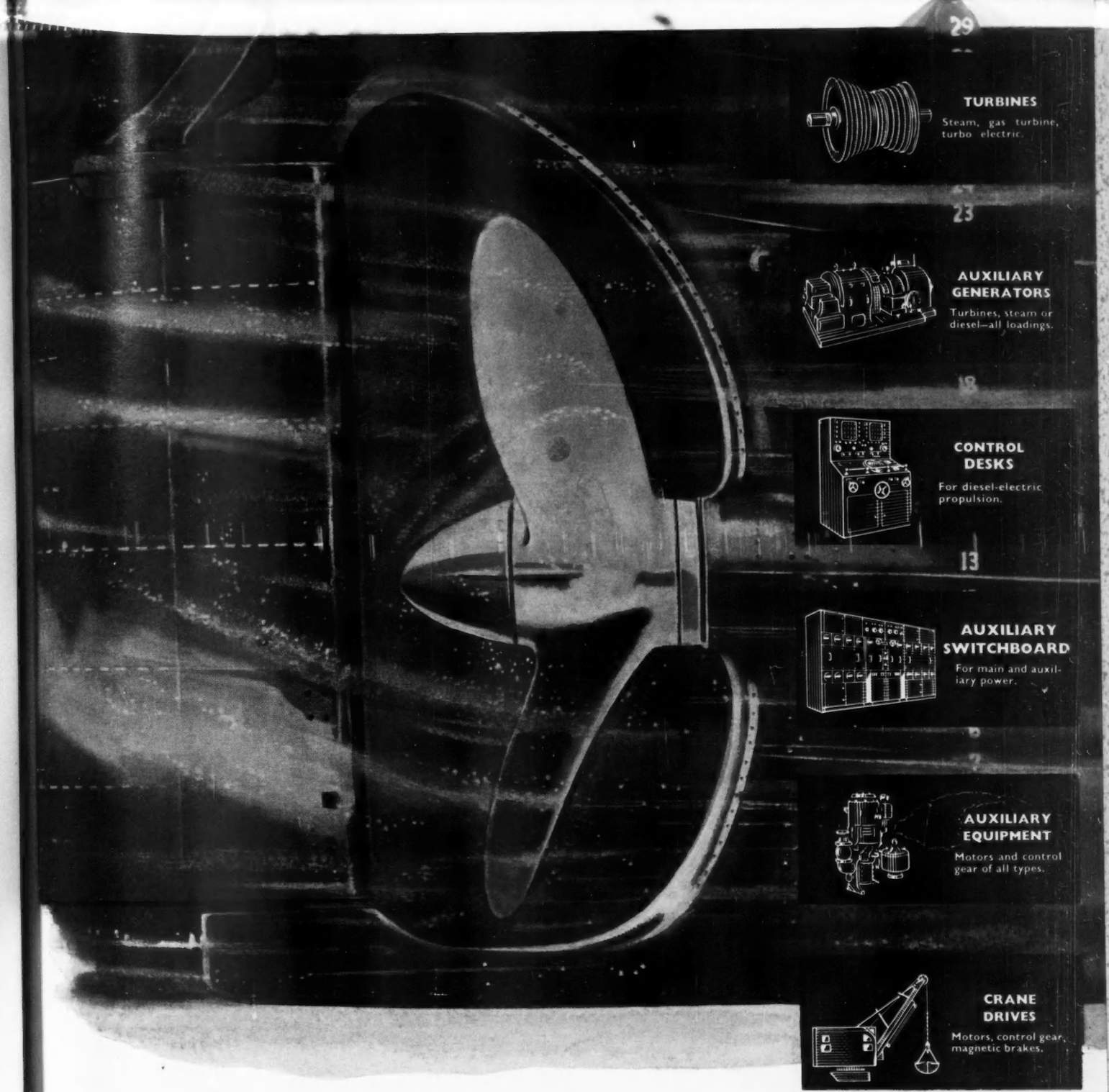

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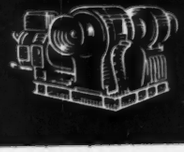

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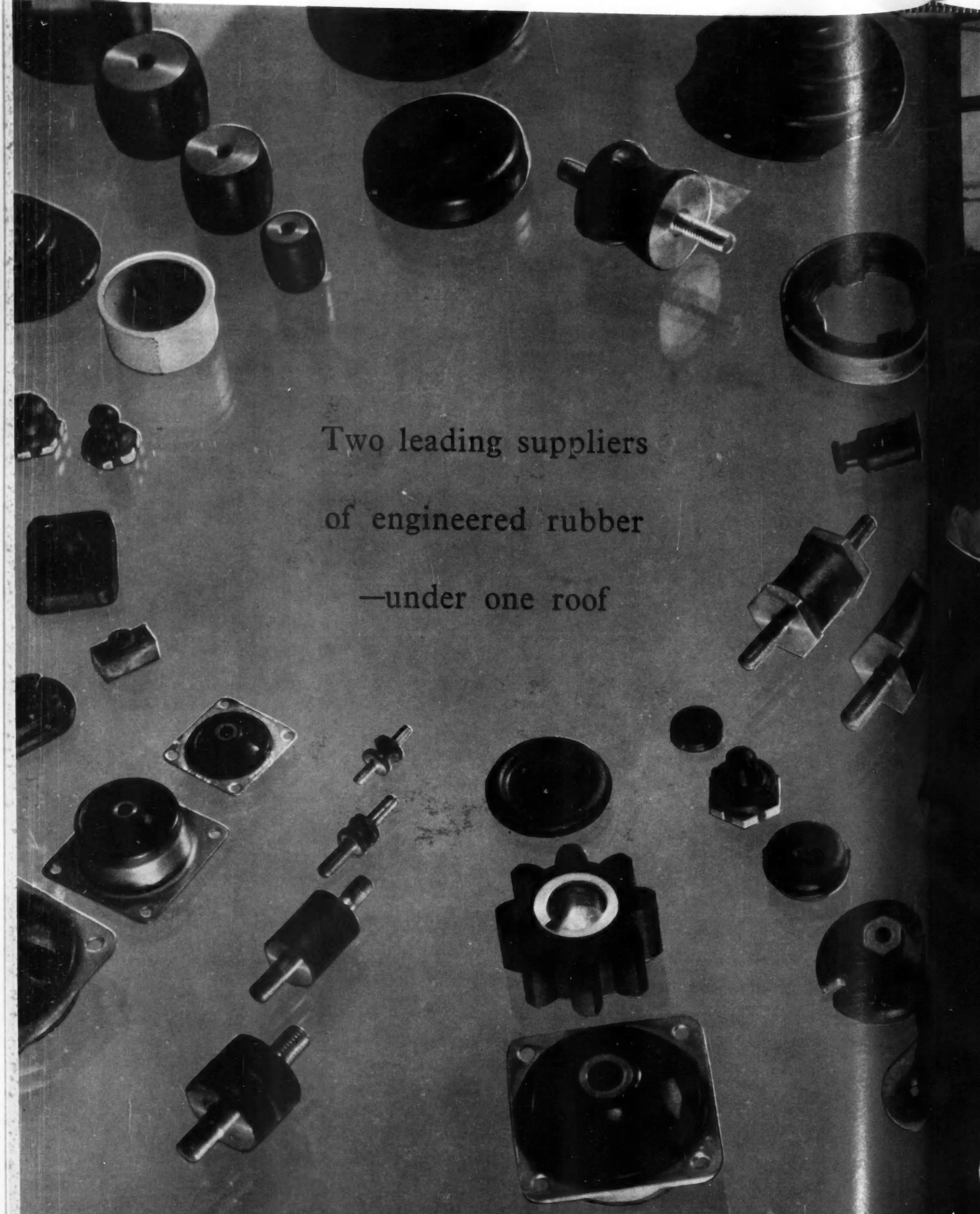

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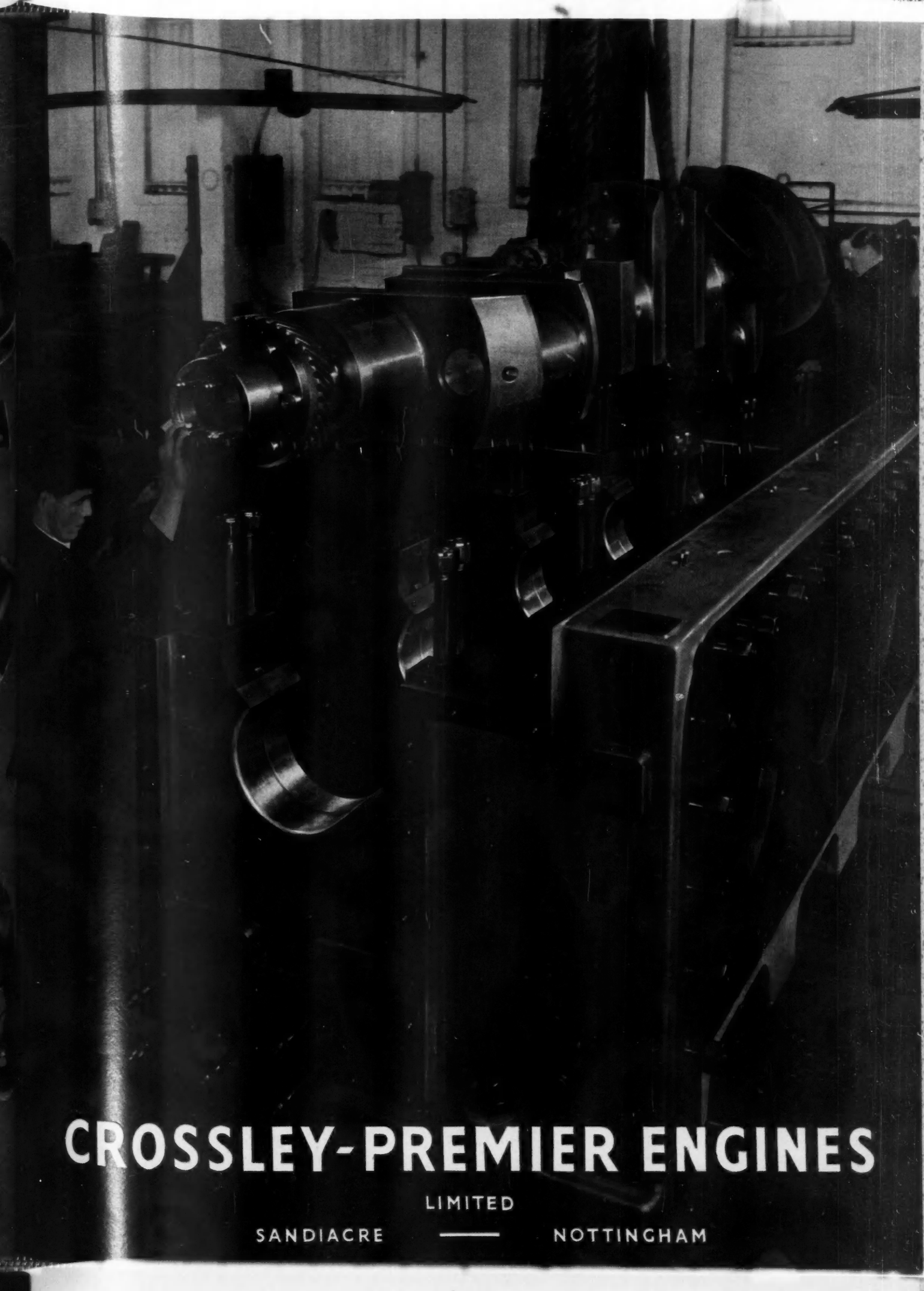

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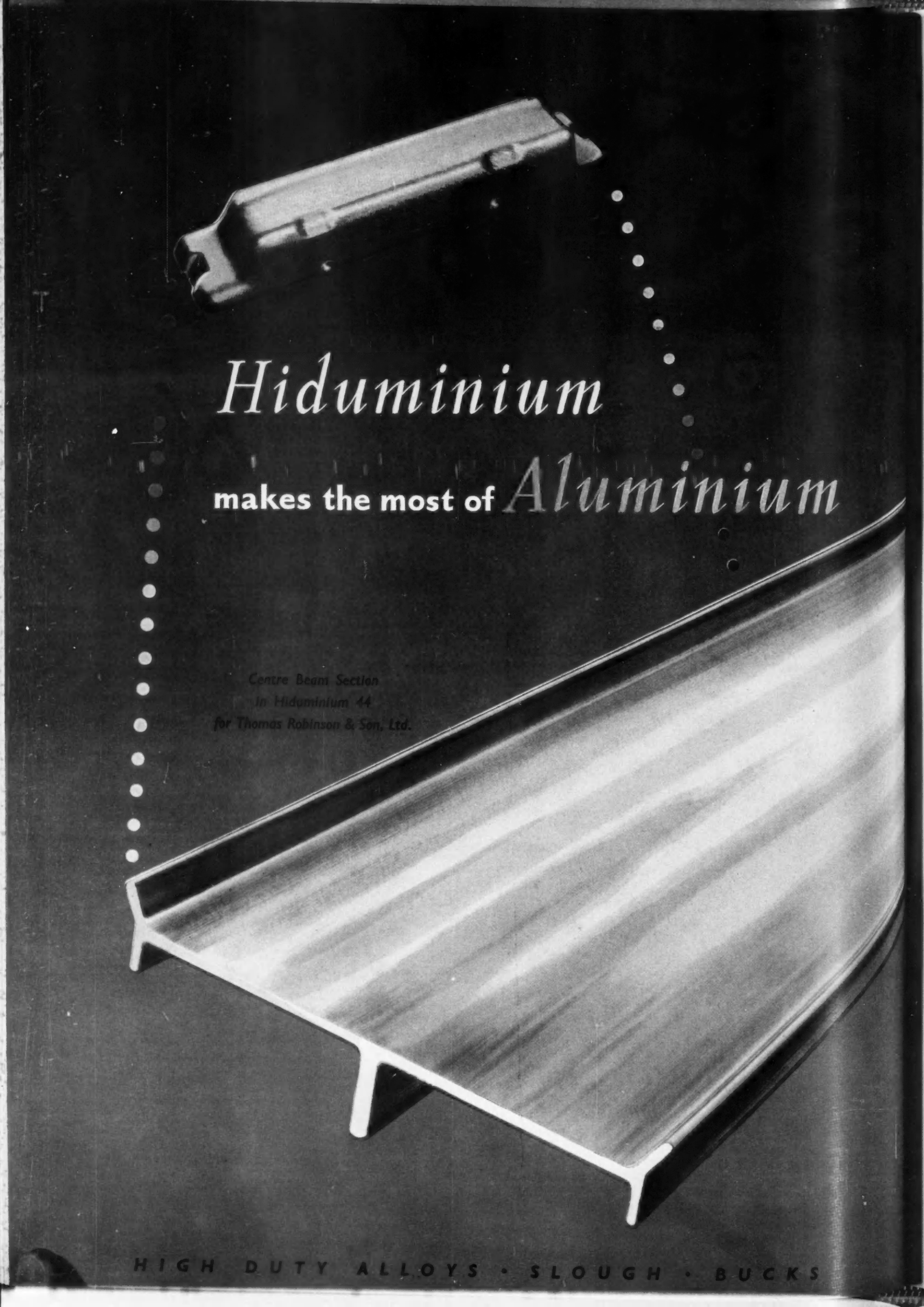
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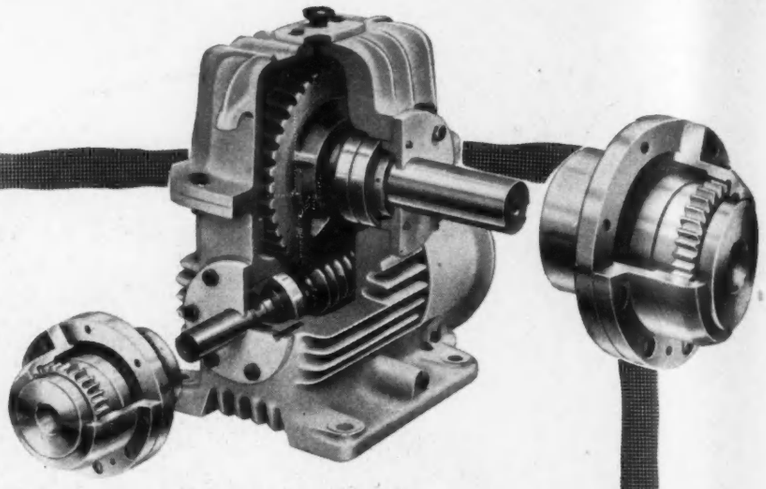

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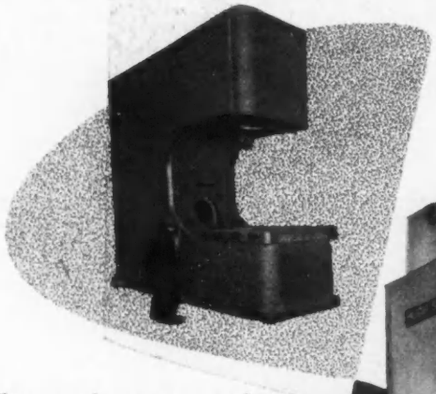

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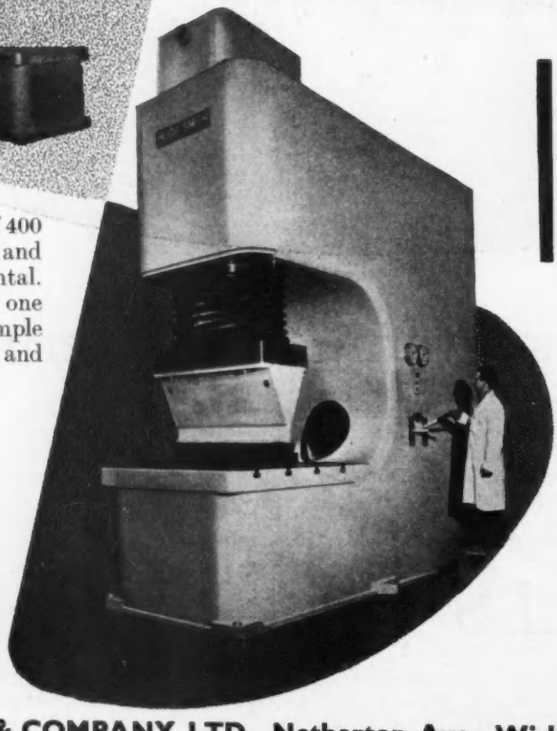
by PICKERING of Wishaw

Welding for Strength / Lightness



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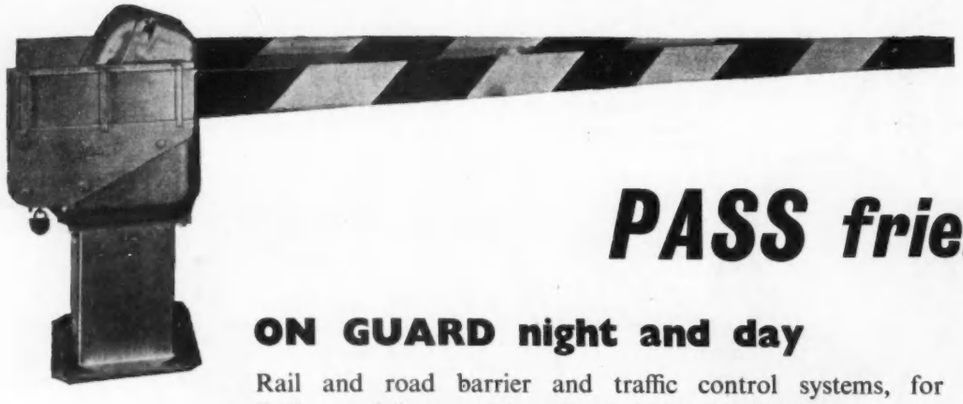

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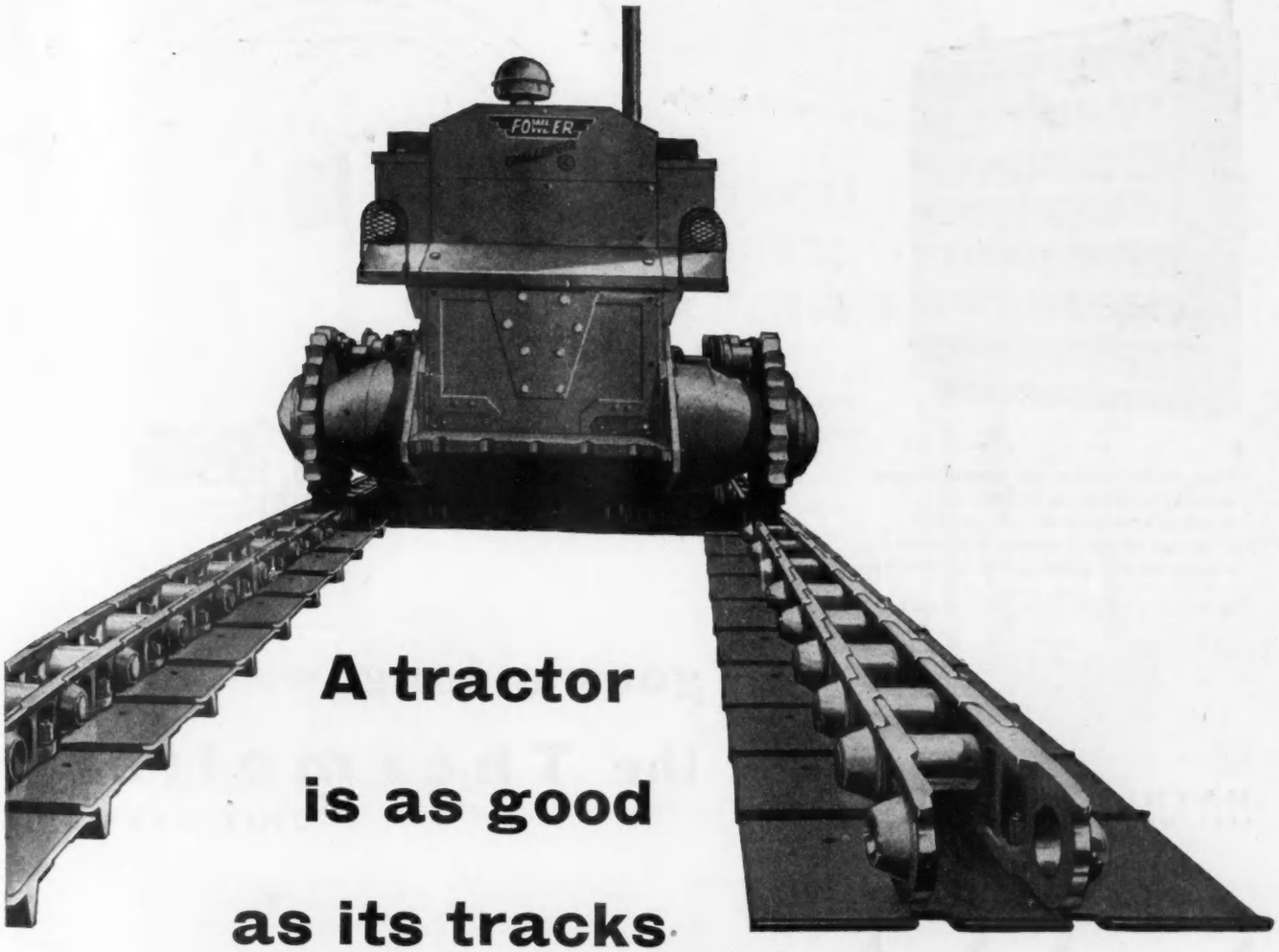

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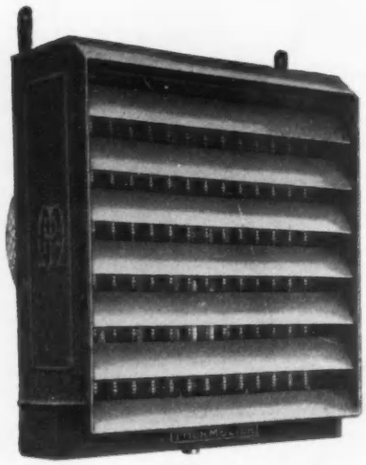

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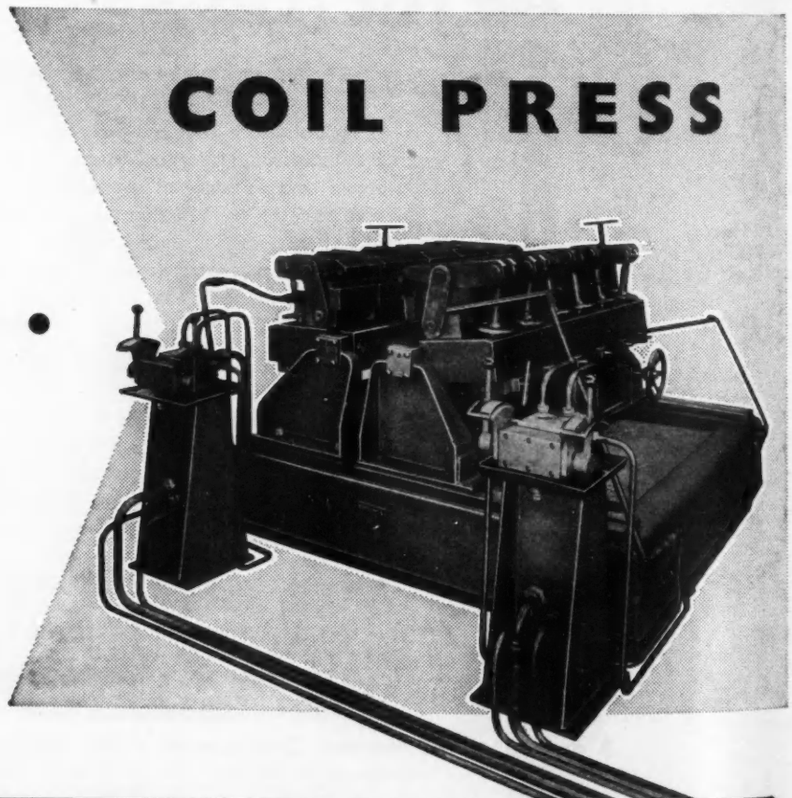

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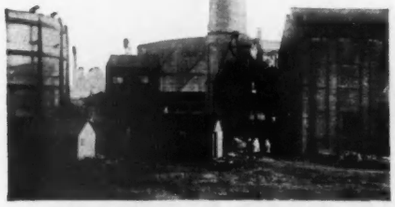
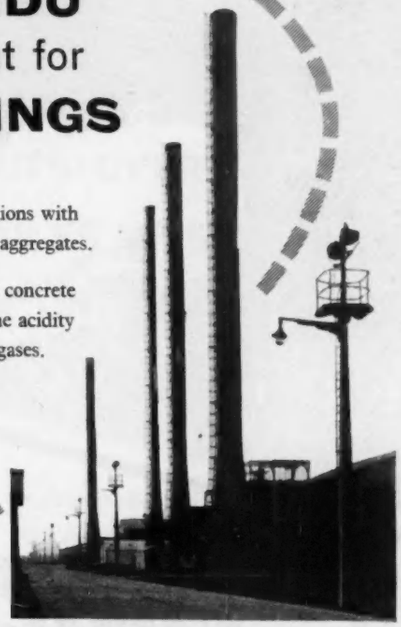
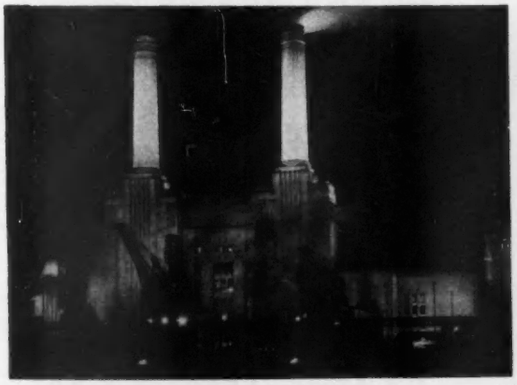


Wallasey Power Station. Ciment Fondu mortar was used for the jointing of the interior brickwork of this chimney.



Shell's Shellhaven Refinery, Essex. These 9 ft. diameter steel stacks have been lined with Ciment Fondu insulating concrete.



Battersea Power Station where chimneys have been lined with Ciment Fondu mortar.

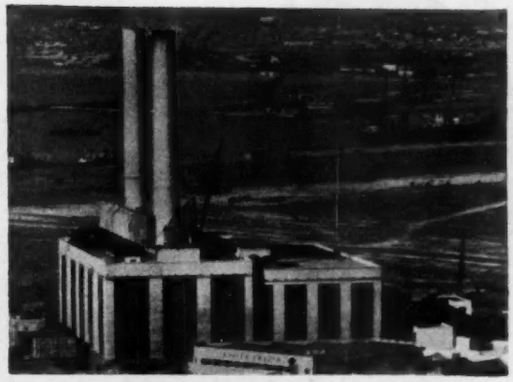


Table Bay Power Station, South Africa. Chimneys gunited with Ciment Fondu mortar.

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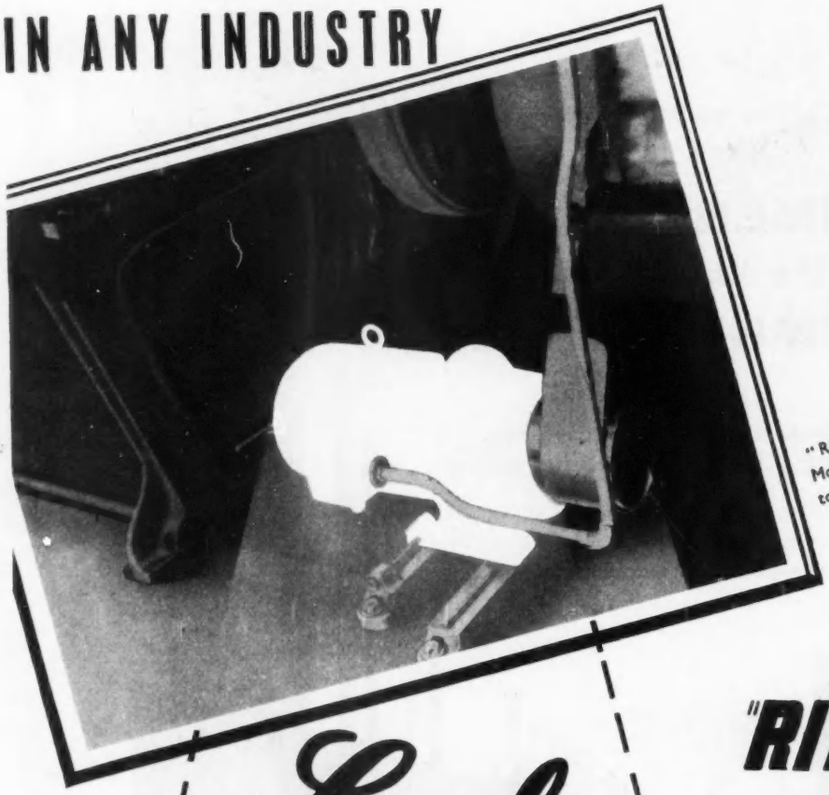

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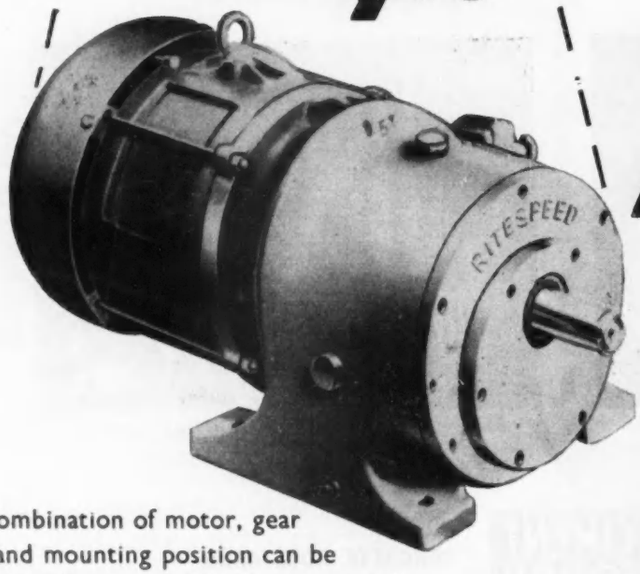

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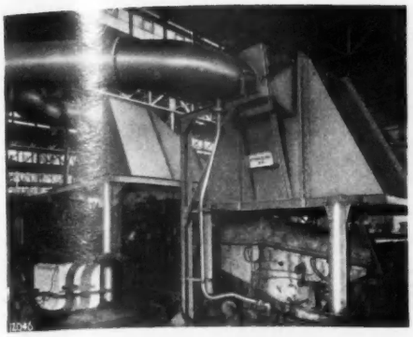
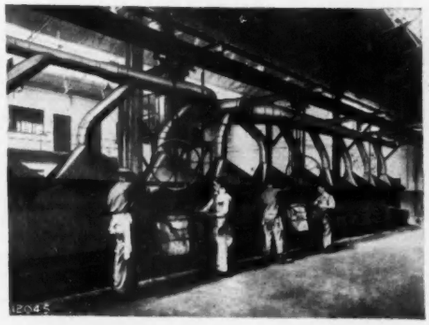
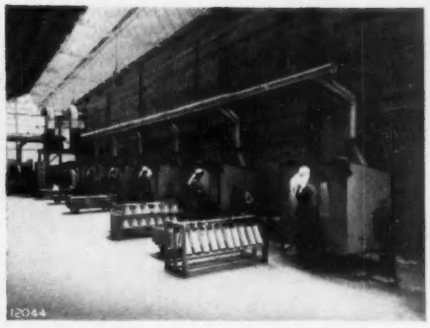


Fume Exhaust from Batch Pickle Plant



Fume Exhaust from Foundry Pouring Station



Fume Exhaust from Spray Booth

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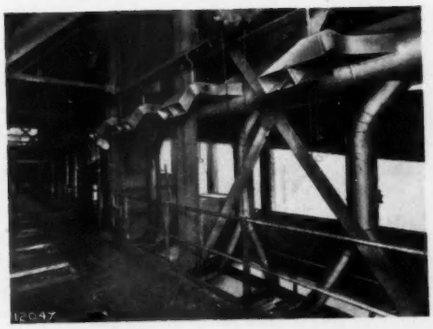

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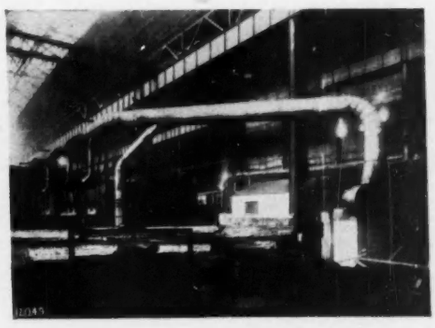

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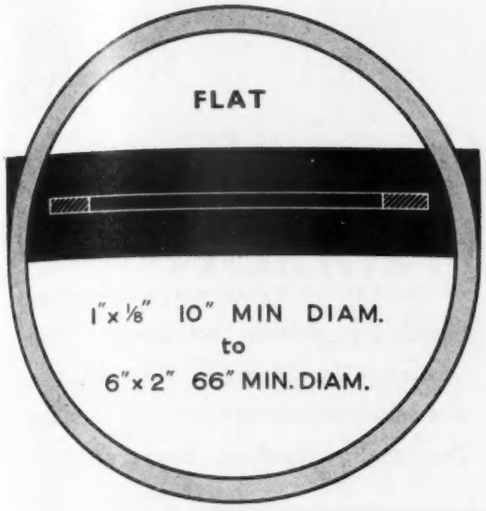

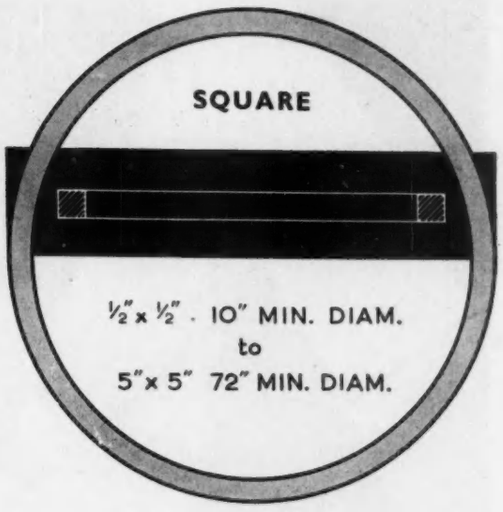

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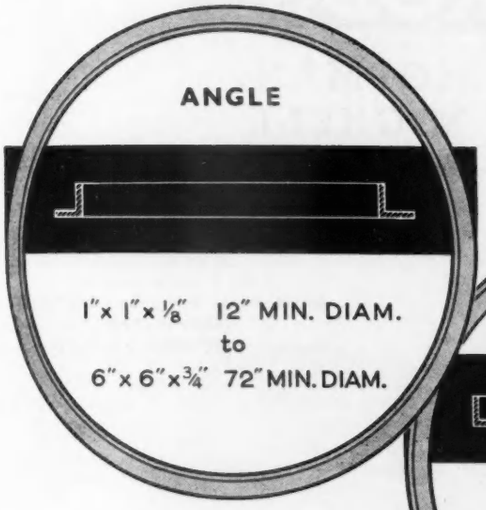

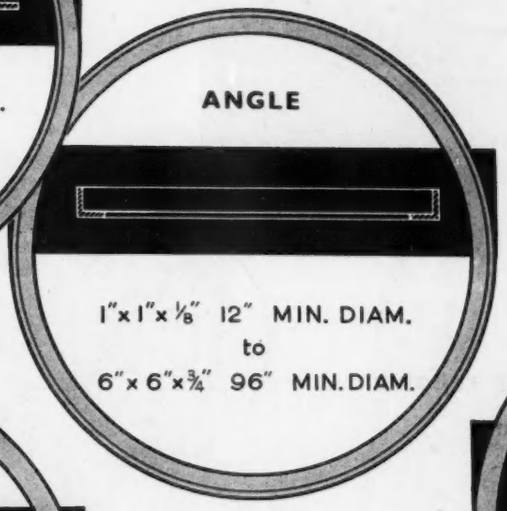

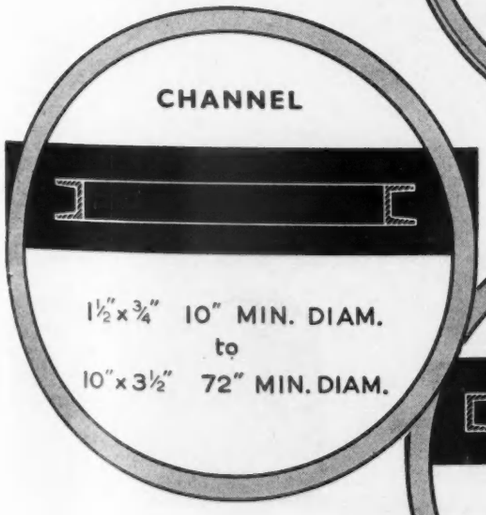

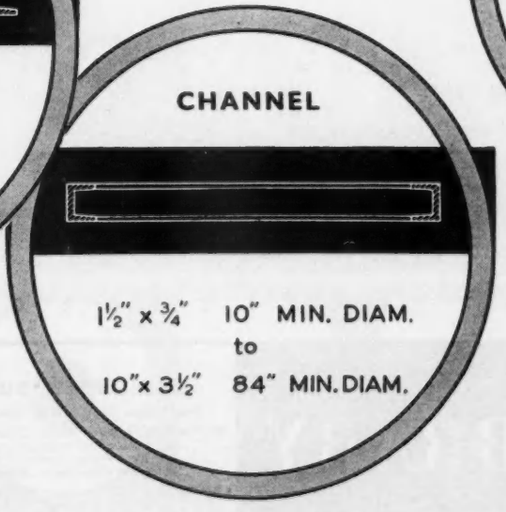

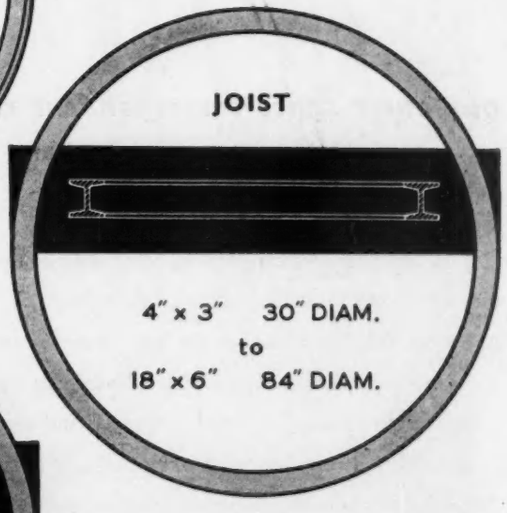

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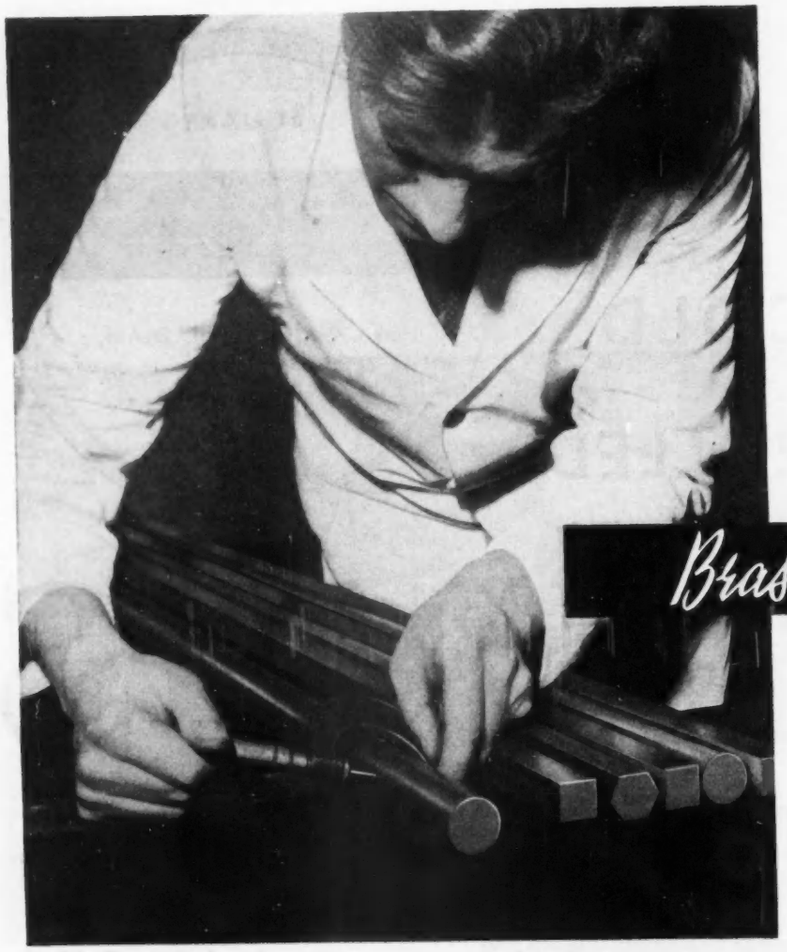

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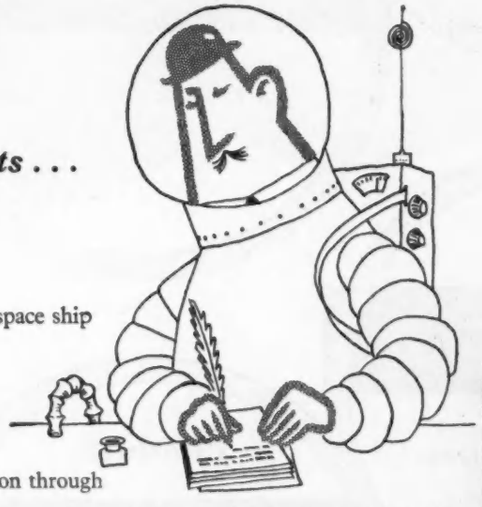

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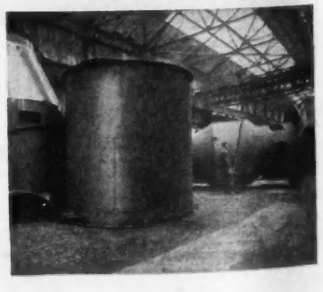

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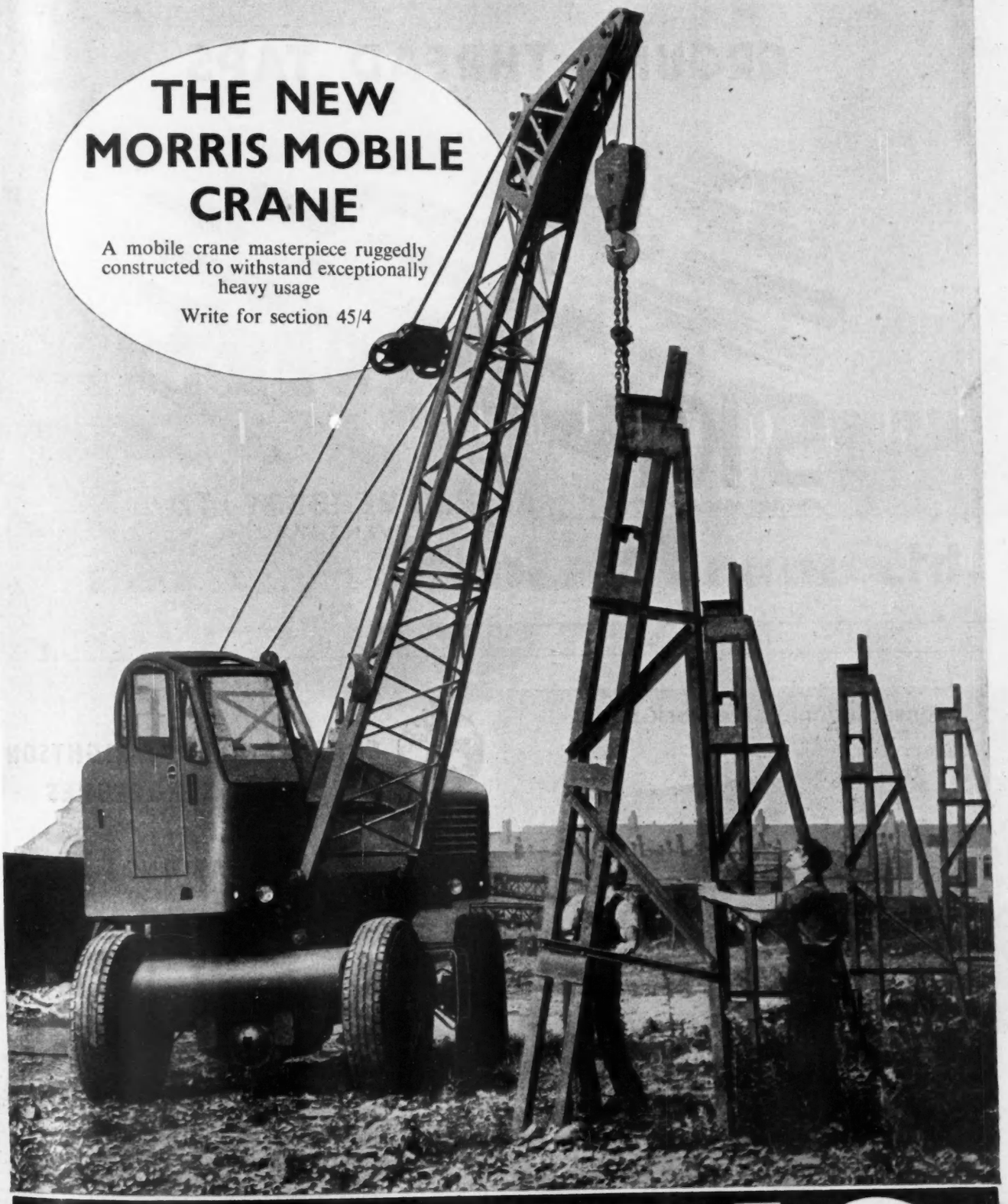

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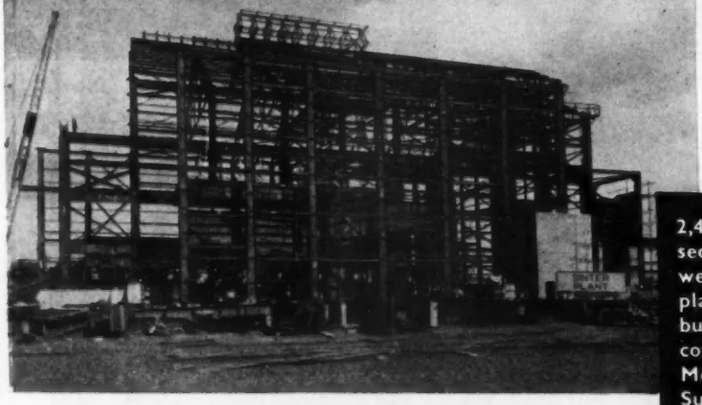

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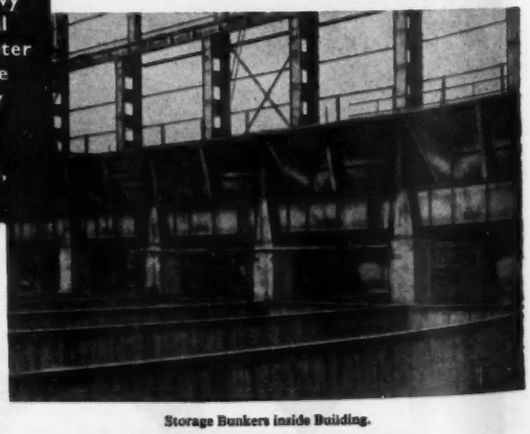

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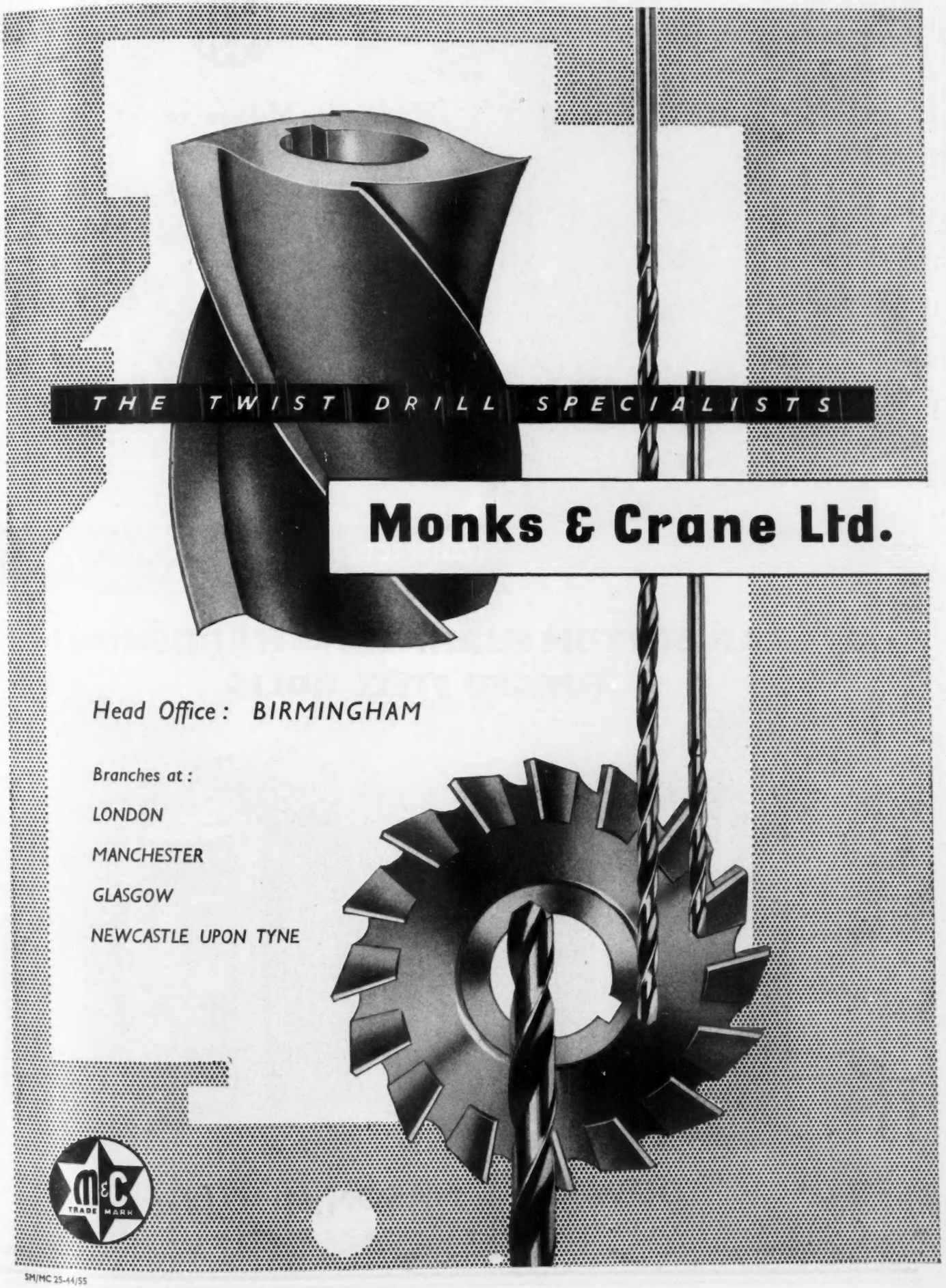
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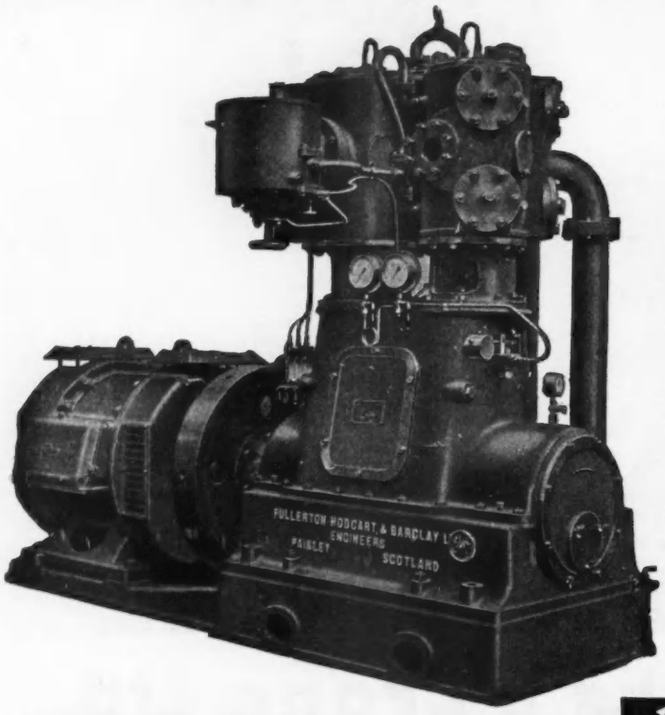

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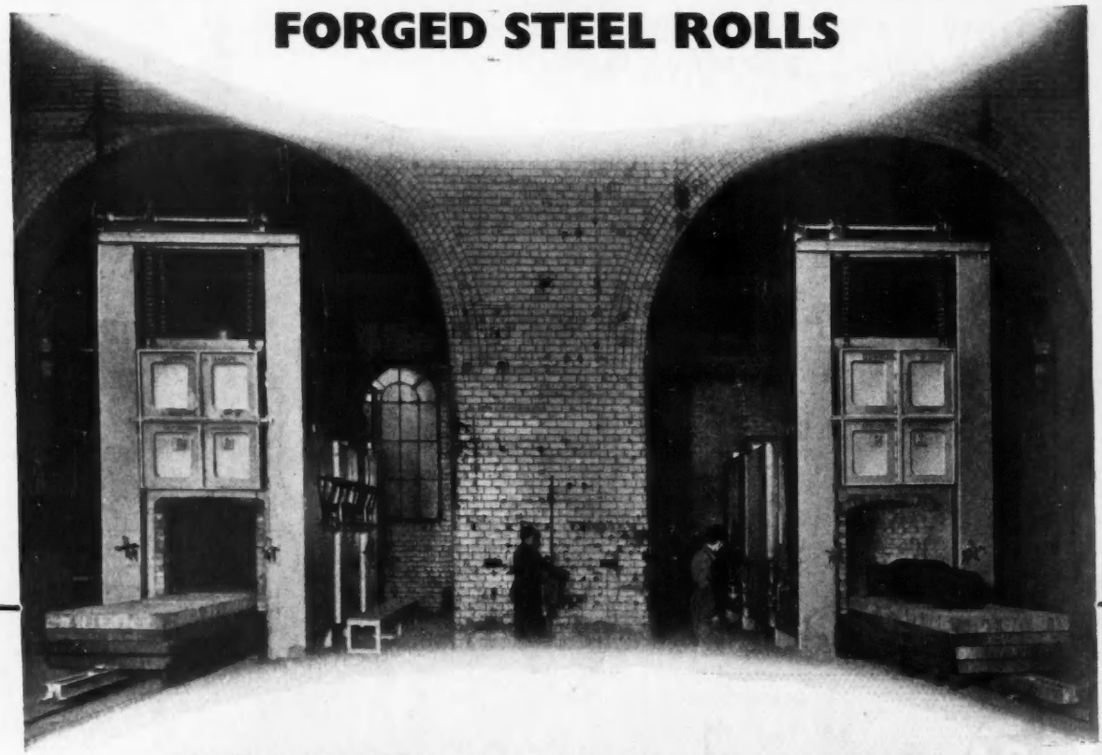

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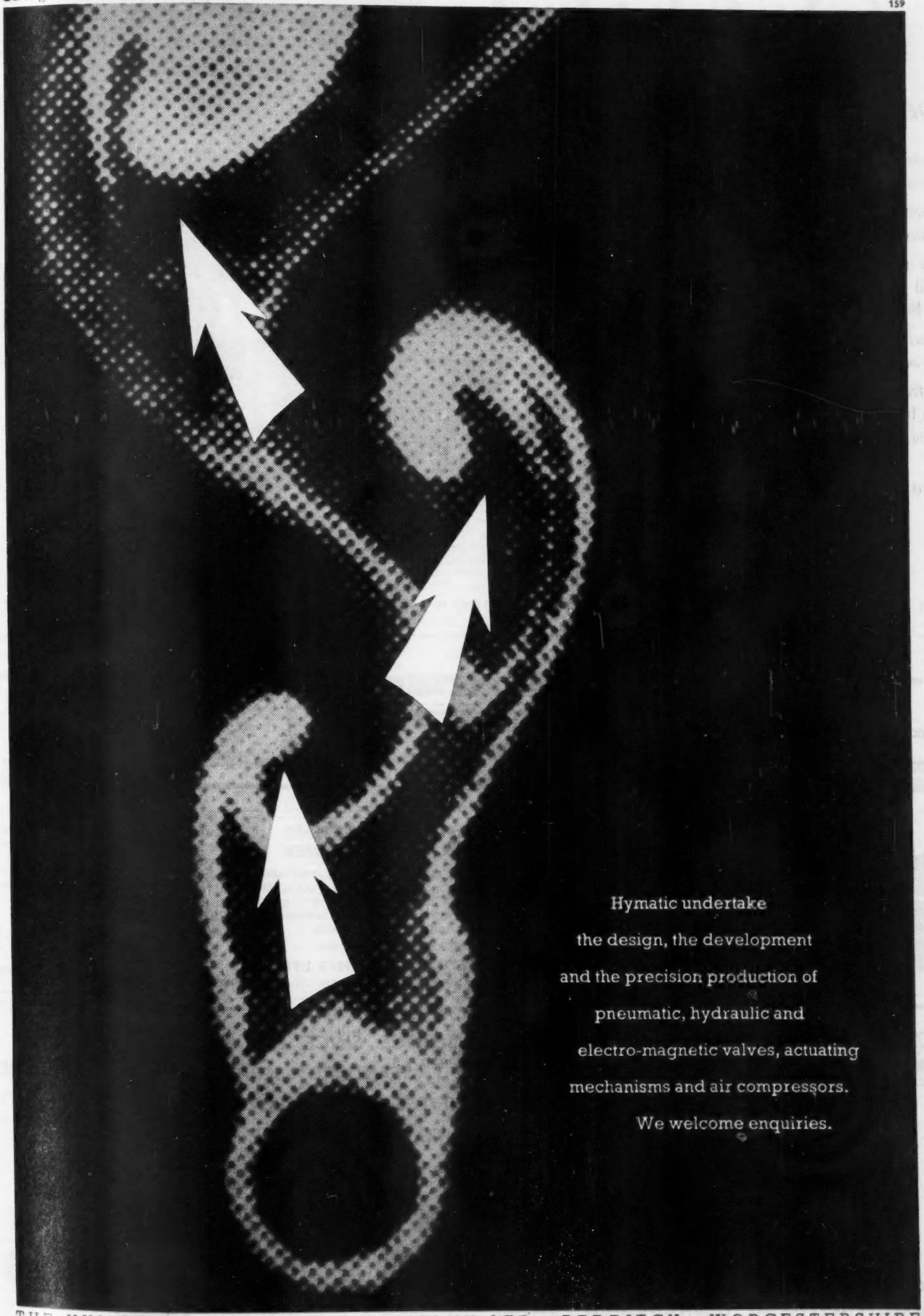

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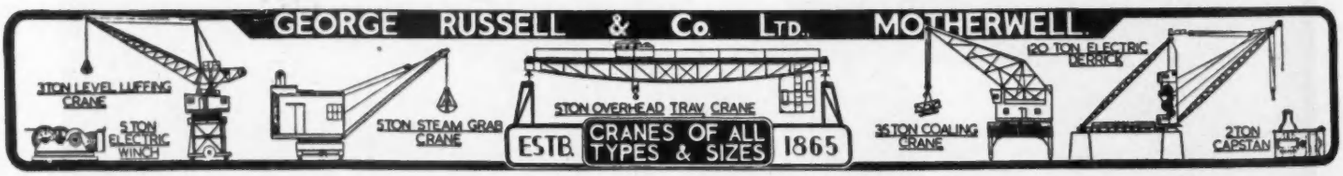
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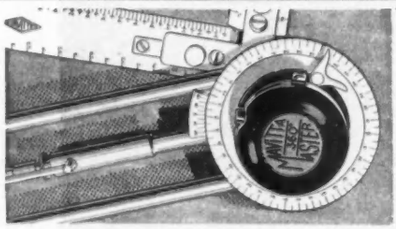

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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4708 JUNE 1, 1956

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A DYNAMIC STATE

THERE is danger for a nation which is always taking its temperature and feeling its pulse, as a Very Great Man exclaimed at one of the most anxious periods of the war. The discussion of how dynamic a society Britain is could produce an atmosphere of social and economic valetudinarianism against which no one felt it possible to struggle and in which all became hopeless pessimists: an attitude of mind which can easily pass into one of defensive complacency.

If we are to face and overcome our real difficulties we need to make a cool and reasonable appraisal of what we have achieved as well as of where we are failing. The main criticism of the pundits, who are mostly economists, is that we are not investing enough, that our business men are unenterprising, that our manual workers are restrictive and receive more in wages than they earn, and that our brain workers receive, after tax, much less than is needed to provide the incentive to responsible effort.

All these things may in part be true, but the engineer who looks around him must sometimes wonder how accurate the statistics are. The vast new chemical works, oil refineries, power stations, motor car factories, new towns and other signs of industrial activity that are to be seen on every hand have not been built by a decadent people. The ships, the gas turbines, the atomic power stations, the electronic equipment, the new agricultural and mechanical handling machinery are not the products of stale brains; and the young men and women taking courses at technical colleges and universities in numbers many times those of pre-war are hardly lacking in ambition. The world speed records on land, on water and in the air could not be held by a nation lacking productive power or self-confidence, even if it is not doing enough.

It is said that America, Russia, Germany are more dynamic societies than Britain; but what does this generalisation mean? The political dynamism of Russia, like that of pre-war Germany, is to be resisted but certainly not copied. Investment in a country during its period of industrialisation, as in Russia, or after war-time destruction, as in Germany, is bound to be at a high level. In the United States the population is increasing faster than anywhere else in the world. The period that has elapsed since the years of immediate post-war reconstruction is too short in which to compare the underlying economic trends in these countries and our own.

That the will to expand exists in some parts of British industry is shown by the rapid recovery in the post-war years and by the investment boom of the last two. Much more remains to be done, particularly in some of our older industries, and the fact that the Government has had to clamp down on investment to prevent inflation is a serious set-back.

There is no doubt that the greatest single handicap to a bigger programme of industrial expansion is the attempt to maintain our national prestige by extensive military commitments which are beyond our capacity. The Chancellor of the Exchequer himself has drawn attention to the effects of our defence expenditure, so much larger than that of our European competitors, on our ability to invest. In a military sense we can no longer play an independent role all over the world, and the attempt to continue to do so must overtax our economic strength. There is a growing realisation that, in the era of nuclear weapons, power and influence for all but the giants among nations will not lie in world-wide territorial possessions but in scientific and industrial expansion.

The official adoption of this point of view would make the economic task seem less demanding and, by reducing its extent, encourage the acceptance by the people of this country of that restraint in their present demands without which wealth creating capital formation is impossible. Higher production and restrained consumption are not, however, enough. Changes are needed in industrial jobs and in industrial habits if we are to reap the benefits of scientific discovery and technological progress. It is here that there is the greatest cause for anxiety, for change conflicts with the essential conservatism of human beings in a settled society whose institutions, including its trade unions, have long traditions. There are certain social attitudes in our country which need changing. The first of these are the relics of that snobbish hostility to the practical arts which, as Sir Maurice Bowra pointed out in his Graham Clark lecture, our governing classes inherited from the ancient Greeks.

There are welcome signs that this is changing as more and more boys from grammar and public schools enter productive industry, but these new entrants, with their better opportunities for promotion, may strengthen within industry itself those class differences which are so much more pronounced a feature of our social scene than in that of our competitors. In the countries which are exceptionally dynamic, although there are certainly greater divergencies in personal incomes, there are far less in speech, in social customs and education and it may well be that these differences act as a deterrent to that sense of urgent common purpose which seems to be lacking in some industries.

It is perhaps through changes in social

behaviour, both at home and abroad, rather than in alterations to material incentives, that we shall release the energies and the talents of our people that are to-day not being fully used. There are signs that these changes are slowly taking place, and the results may well astonish the jeremiahs.

* * *

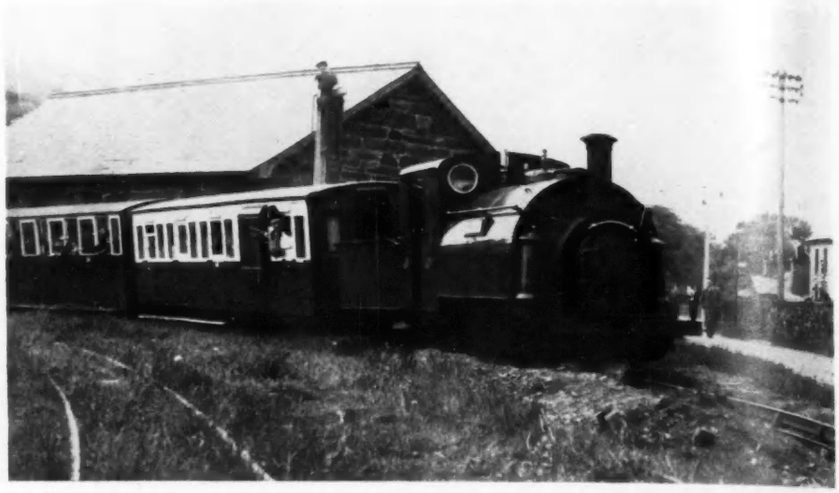
Plain Words

It is the fashion to talk of the need for economy in the use of fuel—talk largely directed against that menace of civilisation, the open fire. It does not give out the heat it could and it produces smoke in large quantities. The Institute of Fuel's recent conference examined the practical economics of domestic heating, as did Mr. W. F. B. Shaw's article in ENGINEERING of April 20 and 27. Dr. G. E. Foxwell, summing up at the conference, said that more than one present had complained of " mental indigestion." They " had heard the priests of the several fuels crying aloud importunately to high heaven, like the priests of Baal 3,000 years ago, beseeching the housing authorities that may reside there to bring down fire into their several appliances." But perhaps they, too, are deaf or sleeping. Certainly extremely little has been done to implement the Simon report of ten years ago.

According to the Parliamentary Secretary to the Ministry of Housing, good domestic heating practice would come to pass " through the enlightened self-interest of millions." Possibly. Unfortunately, " self-interest " usually includes cost, and items like good insulation for a house have to be paid for. That is why, when building costs rose recently, the first item deleted by many local authorities was insulation. Consequently, a properly insulated house is still a rarity in new building and usually is the result of a determined owner who has imposed his will on a reluctant builder and architect, or who has cut all argument and constructed the dwelling himself. Perhaps it is not altogether fair to include the architect in this for he, too, is governed by cost. After all, in many continental countries, and in North America, double glazing and lined walls and roofs are standard practice, and the Simon committee reported that in the countries concerned " the householder has to burn less than half the amount of coal needed by a British householder to secure an equal amount of useful heat in the house."

However, not all this heat loss is due to bad insulation—some of it goes up the chimney, to the benefit of Mr. Grimes, corrosion experts and, occasionally, the local fire brigade. By using one of the available convector heaters, much of the heat from the burnt gases can be recovered, but unfortunately these appliances require skilled installation. It is reported that some 70 per cent. of complaints regarding solid-fuel appliances are due to bad installation. Also, it is far easier to fit such an appliance in a new house than it is to adapt the old ones, in which the majority of people live, and of which only about one-quarter are owner-occupied. Even the best landlord is reluctant to incur extra expense on a house with a controlled rent, particularly an expense which will benefit the tenant only.

Apart from the hot gases, smoke is the other loss up the chimney. Special fires for burning smokeless fuels are available in aesthetically pleasing designs, but unfortunately the cost of most smokeless fuels per ton is higher than ordinary coal, and moreover such fuels are frequently in short supply in mid-winter. Consequently, as in so many plans for benefiting mankind, the whole question boils down to one of economics. As Sir Alfred Egerton remarked in his opening address to the conference, when reporting on the results of experiments with a group of tenants in test houses, " the conclusion to be inferred from this work was that the standard of heating adopted was mainly dependent on their (the tenants') ability to spend . . ."



First train of the 1956 summer season leaves Portmadoc station for Minffordd.

"MOST WONDERFUL RAILWAY IN THE KINGDOM"

The continued operation of the oldest passenger-carrying narrow-gauge railway in the world has been assured by devoted voluntary efforts during the past few years. Once described as the most wonderful railway in the kingdom, the Festiniog Railway, in North Wales, was closed to passenger traffic in 1939 and to freight traffic in 1946. For eight years it was abandoned and fell inevitably into an almost hopelessly derelict condition.

Some of the reverence with which the Festiniog Railway was regarded in the Nineteenth Century is apparent from the numerous articles which were published in this journal in the 1860's and 1870's. There is humour too: " Sheep strayed upon the line, and we should ourselves have made Welsh mutton of a small flock of them, last Saturday, had they not considerately jumped in time down a steepish embankment. Mr. Fairlie was present to observe the working of his new engine—the ' Little Wonder '; an engine constructed on his double-bogie system—and by an unexpected coincidence Lord Alfred Paget and Mr. Moon, the latter the chairman of the London and North-Western, happened to be at Duffws, and came down to Portmadoc with us, Lord Alfred doing a considerable portion of the line on the buffer beam. The din was too great for much conversation, but from a certain action of His Lordship's facial muscles it was fancied that there could be made out the muscular as distinguished from the vocal, pronunciation of the words ' wonderful—wonderful.' To ourselves, who have had to do with railways for a quarter of a century, it was uncomfortably wonderful, yet wonderfully comfortable."

Not all of the 13 miles of 1 ft. 11½ in. gauge track can be re-opened. In July last year the Ministry of Transport Inspecting Officer of Railways authorised the running of passenger trains across the " Cob "—the causeway which runs across the estuary, as shown on the opposite page, and which carries a road as well as the single-line Festiniog Railway. This line conveys tourists from Portmadoc to a beach on the south side of the estuary, and although it is short and the distance could be walked, it carried over 11,000 passengers in seven weeks last summer. Since then more hard work has permitted the opening of the line as far as Minffordd, a station farther up into the hills where the track crosses the old Cambrian line of the Western Region.

The summer service this year was formally opened on May 19. The first train is shown above leaving Portmadoc station, hauled by " Prince," an 0-4-0 saddle tank engine with tender, 93 years old, which at present is doing most of the work on the line.

The restored Festiniog Railway will depend for its receipts on passenger traffic, but the line was built to serve slate and other quarries in Merionethshire in 1832. It was constructed as a horse tramway to bring the slates down from Blaenau Ffestiniog to the busy harbour of Portmadoc. Among stipulations about the construction of the line which were included in the Parliamentary Act was one to the effect that the locomotives should consume their own smoke, but so far as we can ascertain this provision does not seem to have been complied with. As a horse tramway for carrying slates a distance of about 13 miles and a drop of about 700 ft., the line carried trains of 50 or 60 wagons which ran down loaded under the control of brakesmen and were then hauled up empty or with miscellaneous stores by horses. The horses came down to Portmadoc in special wagons, one of which is still to be seen at the station there. The average gradient for the line is 1 in 92 and the steepest part is 1 in 60. The track passes through some of the most glorious country of Snowdonia (it is, as the map shows, only a few miles south of Snowdon).

FIRST STEAM ENGINES

The line prospered in the Nineteenth Century. Slate traffic increased to such an extent that the possibility of providing steam locomotives was examined and, in 1863, Mr. C. E. Spooner, the secretary and engineer of the Festiniog Railway, gave an order to Mr. George England to design and construct two 0-4-0 engines. " Prince " was the first and " Princess " the second, and they were so successful that two others were built later. They had the remarkably high boiler pressure of 200 lb. per sq. in. Each weighed 7½ tons and cost £900 to build. Robert Stephenson himself had said that steam on so narrow a gauge was impossible, but experience on the Festiniog Railway wholly disproved his view. The little engines hauled 50 ton trains on the Welsh mountains at 10 to 15 m.p.h., and after four years of working they were reported never to have run off the rails. Passengers were carried experimentally, without charge, in 1864, and a regular service for passengers was commenced in January, 1865.

By 1869 the Festiniog Railway was carrying 130,000 tons of goods and 145,000 passengers per annum. The capacity of the line appeared to be insufficient, at any rate with the 0-4-0 tank engines, but the necessity of having to double the

line, which surely would have been a most difficult operation, was put aside when Spooner decided to employ Mr. Fairle's patent double-bogie locomotive. "Little Wonder" was built in 1869 and promptly took a load of 140 tons at 15 miles per hour. Unofficially, apparently, she was sometimes known to do 42 miles per hour on a track where, to quote an article in ENGINEERING, the curves were sharp enough to be called "corners."

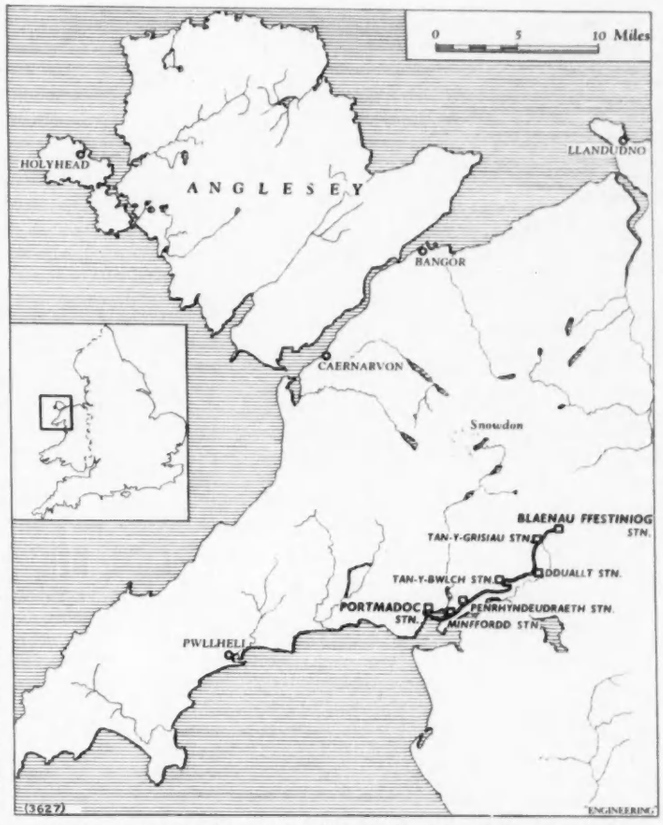
The railway company was paying 30 per cent. dividend on its original capital and visitors from many foreign countries came to see it. At that time there was the controversy over the merits of narrow-gauge and broad-gauge systems and the Festiniog Railway was held up as a shining example of the practicability and profitability of the narrow-gauge system. An Imperial Russian Commission visited it in 1870, together with representatives of railways in India, France, Norway, Germany and Sweden. All the engineers who went to see it in those days were impressed by the efficiency and good condition of the lines. Certainly good maintenance must have been essential, for the single-line track traversed extremely difficult country and was carried in many places on dry stone walls or embankments. With a train 1,200 ft. long, as was common practice at that time, the wagons and coaches snaked along in sharp loops down the mountain sides.

In a leading article in 1872 entitled "Festiniog as a Type," we said "There is, however, one point to which we are bound to call attention, which gives to the line a greater advantage than others can hope to enjoy. It has Mr. Spooner, C.E., for an engineer, and this gentleman shows something more than professional skill in his work; he shows an earnestness and enthusiasm, we may almost say an absolute devotion for the Festiniog Railway; the line from end to end is constantly under his eye; and every detail of construction, management or repair, receives his personal consideration. We suppose it would be difficult, if not impossible, to find elsewhere 14 miles of permanent way similar to that laid down from Portmadoc to Dinas. We notice from the last few days that the constant heavy rains which have deluged that district in common with all the rest of England (*sic*) have had no effect upon the ballast; there being no signs of subsidance or any shifting of the sleepers, whilst the rigid fish plates employed throughout the line maintain all the joints in a perfect condition."

END OF SLATE TRAFFIC

The fortunes of the Festiniog Railway began to decline before the first World War when the slate traffic dwindled, though the end for passenger traffic did not come until September 16, 1939. Slate trains were worked for some years after that from Blaenau Festiniog to Minffordd, but by 1946 the directors of the company at that time decided to close the line.

It is not, perhaps, surprising that the country in which, more than in any other, railways were fostered, and where the steam locomotive is only slowly being replaced by Diesel and electric traction, there should be a sufficient number of people so interested in the Festiniog Railway as to relish the prospect of working on it with their own hands and putting time and money into it so that it can operate once again. The Festiniog Railway Society was formed in 1951. Mr. A. F. Pegler, vice-chairman of the Northern Rubber Company and member of the Eastern Area Board of the British Transport Commission, took an active part in the affairs of the Society and succeeded in acquiring a controlling interest in the railway in 1954. There are about 600 members of the Society who help in different ways, but the railway is run by the company, whose directors include an engineer, a surveyor, an accountant and a solicitor—they receive no remuneration except the pleasure they and everyone connected with the railway derive from it. The Festiniog Railway is under the full-time direction of the manager and engineer, Mr. A. G. W. Garraway, M.A., formerly an engineer on the Eastern Region of British Railways.



Sketch map showing the area in which the Festiniog Railway operated.

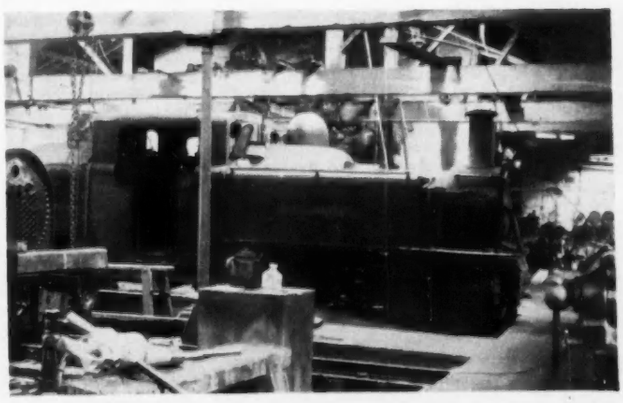
Apart from "Prince" there are two Fairlie locomotives, one of which is expected to be in traffic this summer; it is being overhauled at the Boston Lodge Works, which are situated at the opposite end of the causeway to Portmadoc. The works still contains some remarkable old machine tools.

SUNDAY WORK

The voluntary helpers come from Merseyside, Derby, Manchester and London. The local people of Merionethshire now approve of the rather unorthodox officials and volunteers, though at first they were not at all keen, especially as the wild men from England were in the habit of working on the Sabbath. But how otherwise could spare-time railwaymen have renewed thousands of sleepers, cleared the overgrowth of years of neglect, repaired and repainted the carriages, overhauled the locomotives, and finally convinced the Inspecting Officer of Railways, early last month, that it was now safe for passengers to be carried from Portmadoc to Minffordd? It is true that a speed limit of 10 m.p.h. is imposed but the F.R. are proud to tell you that it is likely to be raised to 15 m.p.h. in the near future.

No trains are being run on Sundays, except at Whitsun and the August Bank Holiday week-end, in deference to local feeling. This restriction is unfortunate for the revived railway company since a heavy proportion of their tourist traffic could be expected on that day of the week;

In this v... narrow-g... Portmadoc is at the far end of the causeway on which the line crosses the estuary. Boston Lodge locomotive works, before restoration, is in the foreground.



A Fairlie double-bogie narrow-gauge locomotive which is being overhauled in the Boston Lodge works, and is expected to return to service on the Festiniog Railway in July.

for the rest of the week the normal timetable allows for four " up " and four " down " trains in the afternoon until September 22, with additional services in the mornings from the middle of July until the beginning of September. At the moment little " Prince " is doing all the work but the Fairlie engine is expected to help from July onwards. Among the railway's other locomotives is a Baldwin 0-4-0 petrol locomotive which has been fitted with a Gardner Diesel engine and is expected to return to service within the next few weeks.

Sir Henry Tyler, whose name as Board of Trade railway inspector often crops up in the records of the period, described it as the most instructive line in the kingdom. Perhaps, rather ironically, it still is. Certainly it shows what a handful of enthusiastic people can do with a railway which commercially had been given up as a dead loss.

Anyone who would like to lend a hand on the line is invited to contact the manager, Festiniog Railway Company, Portmadoc, Caernarvonshire. Details of membership of the Society can be obtained from the Financial and Membership Secretary, Festiniog Railway Society Limited, 35 Holmwood Road, Cheam, Surrey.

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Letters to the Editor

FROUDE COMMEMORATED

SIR, In reading your account of the new Zagreb ship-model establishment (ENGINEERING, vol. 180, page 662, 1955), I notice that you make the following statement: " It may be remarked that the road in which the houses stand (erected for the staff) is named after William Froude, a distinction which, so far as we are aware, has not been accorded to him before, even in his native England."

In 1942, when the David Taylor Model Basin was being built at Carderock, Maryland, some 12 miles from the city of Washington, D.C., the same difficulty was experienced as at Zagreb in housing the staff in what was then a comparatively rural and isolated area. A housing development was therefore built by the U.S. Government about three miles from the Model Basin, and it may be of interest to your shipbuilding readers to know that in this estate the central area was and is named the " Froude Circle " in honour of the pioneer in the development of ship-model towing tanks.

Yours faithfully,
F. H. TODD,
Chief Naval Architect.

Navy Department,
David Taylor Model Basin,
Washington 7, D.C.
May 18, 1956.

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SIR JOHN COCKCROFT, K.C.B., C.B.E., F.R.S., director of the Atomic Energy Establishment, Harwell, has been awarded the Kelvin Gold Medal for 1956. The Medal is presented every three years as a mark of distinction in engineering work of the kind with which Lord Kelvin was especially identified. The Medal Fund is administered by the Institution of Civil Engineers and the award is made by a committee consisting of the Presidents of the leading engineering and technical institutions in Great Britain. The Medal is internationally regarded among engineers as the highest distinction attainable. Sir John is 59 years of age and has held his present appointment since 1946. He was educated at the University of Manchester and at St. John's College, Cambridge, and is the recipient of the Hughes Medal of the Royal Society, the Ewing Medal, and the Nobel Prize for Physics (with E. T. S. Walton). The last-mentioned award was made in 1951.

MR. G. R. EDWARDS, C.B.E., B.Sc.(Eng.), F.R.Ae.S., managing director of Vickers-Armstrongs Ltd., has been made President-elect of the Royal Aeronautical Society, 4 Hamilton-place, London, W.1, for 1957–58. He will take office in May, 1957.

SUPERSONIC FLIGHT

ROYAL AERONAUTICAL SOCIETY HOLDS DISCUSSION

Not very many years ago, aeronautical opinion generally seemed to be that the future of the supersonic air-liner—if indeed there were such a thing—was well beyond the scope of current thought, and that the paths of development of the commercial aircraft and the airborne fighting vehicle were likely to diverge. The recent all-day discussion on " Supersonic Flight," held by the Royal Aeronautical Society in London, has shown that this is no longer the trend of thought and that the supersonic air liner, although still no more than a long-term project, is beginning to attract the attention of the aircraft and engine designer.

The discussion was centred on four aspects of supersonic flight–aerodynamics, introduced by Mr. P. J. Duncton, Fairey Aviation Company, Limited; power plants, introduced by Mr. A. V. Cleaver, de Havilland Engine Company, Limited; structures, introduced by Mr. D. J. Farrar, Bristol Aircraft Limited; and control, introduced by Mr. H. H. Gardner, Vickers-Armstrongs Limited.

Both guided missiles and piloted aircraft were included in the discussion, and one of the points which emerged most clearly was the way in which the piloted machine is likely to follow the path already marked out by the missile designer—but because the human crew is subject to physiological limitations, the problems of the aircraft designer are rather more complex. As speeds increase the ability of the human brain to evaluate a situation and respond rapidly and accurately will become insufficient, and automatic guidance systems will therefore be necessary, as they are in pilotless missiles, to control and direct the aircraft on its course. The crew will still serve a useful purpose in monitoring the automatic system—which, although more sensitive and quicker to respond, is still less reliable than the human brain—and in taking over control if necessary.

INERTIA FORCES

At high supersonic speeds the increasing importance of inertia forces relative to aerodynamic forces is introducing new problems in control and stability, and generally it seems to be accepted that devices for automatic stabilisation of aircraft will have to be adopted. New aero-elastic problems can be foreseen, complex beyond the possibilities of mathematical analysis, demanding the use of free-flight rocket tests; and the exhaustive flight testing that will be required suggests that the limited technical resources available in the United Kingdom could usefully be concentrated in co-operative effort rather than dissipated among individual firms.

On the phenomena of aerodynamic heating, the discussion disclosed little that is new. If the external surfaces can be suitably insulated from the boundary layer, it seems that light alloy may still be attractive for the structure of short-duration supersonic aircraft; but at temperatures above 200 deg. C., titanium alloys will give a lighter structure weight and eventually will themselves be surpassed by stainless steel. The latter may also be preferred where stiffness rather than strength is the main criterion. Probably the aircraft structure will, in fact, be assembled from various different materials. Fatigue data for aircraft structures at high temperatures is very limited; and the problems of fabrication of titanium alloys and stainless steel have not yet been solved by the industry as a whole, although some aircraft manufacturers claim that they have found the way.

POWER PLANTS

On the power-plant side, the air-breathing engines such as the turbojet and ram jet will have variable intakes and exhausts and will require elaborate test facilities capable of feeding air at a wide range of pressures, temperatures and velocities. An increasing diversity of types of engine may be seen—such as the bypass turbojet with a high bypass flow and afterburning in its fan duct, considered by Mr. Cleaver to be " a strong competitor for supersonic honours," and the air turbo-rocket, a modified turbojet in which the compressor is driven by a turbine running on rocket propellants, the compressor air efflux being burned in the tailpipe. Such an engine is being constructed by the Aerojet Corporation of America, and has performance and specific weight characteristics intermediate between those of the turbojet and rocket engine.

FUEL FROM THE SKY?

Further into the future, there is a possibility, once having obtained a certain speed by orthodox means of propulsion, of utilising the aerodynamic heating of a suitable working fluid and its subsequent expansion through a propulsive nozzle to maintain speed; and at altitudes of about 300,000 ft., of sustaining hypersonic flight by utilising the energy of re-association of the naturally-occurring non-atomic oxygen layer by catalytic action in a propulsive duct.

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AIRCRAFT STRUCTURAL PROBLEMS

Fatigue of aircraft structures, the analysis of complex stressed skin structures and the effects of aerodynamic heating were the main subjects of the inaugural lecture given by Professor J. H. Argyris, first occupant of the Chair of Aeronautical Structures in the University of London, at the Imperial College of Science and Technology on May 8. These subjects are three of the areas of the field of aeronautical structures in which Professor Argyris has made personal contributions. The fatigue problem, he said, was far more acute now than in pre-war days, since greater speed led to a larger number of encounters with gusts. Moreover, a typical pre-war material would withstand $1{\cdot}2 \times 10^6$ gusts of 10 ft. per second before failure, as against $0{\cdot}2 \times 10^6$ for typical post-war light alloys. The static design criteria for gusts might lead to excessive dynamic stresses. Aircraft fatigue tests would have to be programmed intelligently if the results were to be meaningful. In the absence of a better knowledge of the physical mechanism of fatigue, designers must concentrate on designing to reduce stress concentrations. A reduction of the working stress of 10 per cent. might lead to an appreciable improvement in fatigue life.

DESIGN BY COMPUTER

The analysis of complex stressed-skin structures with an arbitrarily large number of cut-outs had been accomplished by using Professor Argyris's recently-published force and displacement matrix methods together with a commercially available electronic digital computer. It was announced that this method had recently been accepted as standard by the Society of British Aircraft Constructors. An exciting future development of this technique would lead to " automation " of design, by feeding the computer with data relating to allowable stresses and causing it to search for parts of the structure where these were exceeded. It was, in fact, intended ultimately to use the computer to design the most efficient structure for a given general external geometry. Professor Argyris devoted some time to the various modes of instability in stiffened panels, illustrated by model tests.

The final section of the lecture dealt with the impact of aerodynamic heating on aircraft structures, the effects of creep, and a newly discovered thermal torsional instability of loaded cantilever wings, which was illustrated by a model.

Weekly Survey

Cover Picture: *In order to overcome the voltage variations which normally occur in a power transmission system due to the changes in load, "taps" are taken from the windings of the transformers which enable the ratio to be changed within small limits as required. The illustration shows the tapping leads being assembled on a 132 kV/33 kV transformer.*

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The Lure of the Dollar

There is a grave danger that the cream of British technological students will be lost to the United States unless something is done to induce the students to return to this country, after they have gone there on research scholarships or to take posts with the American companies who are seeking properly trained men here. Lord Chorley, general secretary of the Association of University Teachers, gave this warning in an address given to the Central Council of the Association at a meeting in Birmingham last week. Although he was speaking in support of a resolution calling on the Government to grant permanent deferment from national service to science and technology graduates, Lord Chorley did not consider the students' decision to take up employment in the United States was a deliberate intention to evade national service: "When they get over there and get offered salaries equivalent to £2,000 a year it is a great attraction for a man of 24 or 26 to stay."

The conference was wholeheartedly in support of the resolution calling for permanent deferment. It was also most strongly in favour of improved rewards to technologists, both in the form of higher salaries and better prospects. The President of the Association, Professor J. L. Montrose of Belfast, commented that despite all the "hullabaloo" about the need for more technologists, entrants to universities still showed a reluctance to enter departments of technology, and advocated for university teachers "salaries which compete with those payable outside."

This journal has often stressed the need for a deliberate effort, on the part of Government and on that of industry, to raise the status of the scientifically trained. To quote from the paper by Mr. Bosworth Monck, "The Eclipse of the Engineer to Management," published in ENGINEERING for September 10, 1954: ". . . the fact remains starkly that in the board rooms of well over a third of the public companies in the engineering industry . . . no technically qualified voice is ever heard" and "more than two-thirds of the directorial oligarchy were (in 1952) without technical qualifications." There lies the major weakness of British industry; in this light the reluctance to return of the promising graduates who go to the U.S.A. to further their education can be understood. The remedy is to raise their status as well as their pay and to give tangible proof at all industrial levels that the young technologist will not be led up a blind alley while his university friends who followed one of the so-called liberal professions climb the carpetted stairway to the boardroom.

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Investment—More or Less

Quite the most controversal side of the current official policy of deflation is the selective control of investment in capital goods. Those behind cry forward and those in front cry back. It is, however, that aspect of official economic policy which is of most direct, immediate concern to the engineering industry.

The problem was referred to again last week by Mr. [illegible] F. Spencer, managing director of Richard Thomas and Baldwins Limited and chairman of the Council of the British Institute of Management, in the first paper read to the Production Conference. Mr. Spencer pointed out that if the United Kingdom intended doubling its standard of living in 25 years (a target aired by Mr. Butler when he was Chancellor of the Exchequer) it would have to replace industrial plant much more rapidly than it has recently done. To put this country on the same footing as Western Germany and Sweden, a rate of gross fixed investment of 125 per cent. of the 1955 rate would be necessary. He coupled this with the need for more expenditure on research and the training of scientists and technologists, and singled out the level of industry's stocks and defence as places where the pruning might be carried out.

By coincidence, a similar theme has been aired by Mr. Graham Hutton in the latest issue of the *Westminster Bank Review*. Mr. Hutton emphasises the need to choose carefully not only the amount but the kind of capital equipment need by this country in its present difficulties. It will be recalled that this problem was discussed in last week's Weekly Survey note "Does Deflation Work?" Even the latest issue of the Treasury *Bulletin for Industry* draws attention to the unfavourable comparison between this country's recent performance in the creation of fixed assets and that of other countries. The preoccupation in this case is with the difficulty of maintaining a high rate of investment rather than selection.

Both the problem of the amount of investment and its kind is, in fact, very much with us. In this connection, it is worth recalling that in the United States, where interest rates have also been hardening and recession has taken place in the automobile industry, expansion and modernisation of equipment for industry as a whole are forging ahead. According to the McGraw-Hill six-monthly estimate on capital investment, American industry intends spending £14,000 million on capital development in 1956, which is £1,430 million more than the maximum Government estimate. This represents a 30 per cent. increase on 1955. Among the big expansions, significantly, is that for the automobile industry, and others with big programmes are steel, chemicals, miscellaneous machinery, petroleum and the railways.

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The Diesel Shunter Comes of Age

It is just over twenty-one years since a British railway first placed orders for Diesel shunting locomotives in quantity. The twenty units ordered at the end of 1934, all with electric transmission, were for the former London Midland and Scottish Railway, which had been testing prototypes with electric, hydraulic and mechanical transmission for some years previously. In comparison with the 166 Diesel-electric shunter power equipments for which orders were announced by the British Transport Commission last week, the numbers concerned seem trivial, but they were the first step towards the eventual total of 432 locomotives of this type which has been planned for British Railways.

Ten of the locomotives in the 1934 order embodied the fundamentals of the present B.R. standard Diesel-electric shunter design, notably the 350 h.p. engine and the two nose-suspended traction motors with side-rod drive to the three coupled axles. They were built by the English Electric Company, Limited, which had provided a prototype for test on the L.M.S. some ten months previously. The other ten were by Armstrong-Whitworth, whose design had the same wheel arrangement but a single motor geared to a jackshaft from which the side-rod transmission was taken to the coupled wheels. The first English Electric locomotives had single-reduction gearing, but double-reduction gears are now standard for the 350 h.p. Diesel-electric shunter, of which the mechanical parts to-day are built by British Railways themselves. Last year forty of the locomotives went into service with power equipments supplied by B.T.H., Crompton-Parkinson and G.E.C. Each builder introduced features of his own in connection wtih motor-suspension, transmission, facilities for de-meshing the gears when the locomotive has to be towed, and other details, while two engines new to this design—Lister-Blackstone and the Crossley two-stroke—were used. In the B.T.H. and Crompton-Parkinson equipments the motors were connected permanently in parallel instead of provision being made for off-load changing of the connections according to the duties to be undertaken. The B.T.H. design, further, used an exciter with characteristics which enabled resistance control of the main generator excitation to be dispensed with, the locomotive being controlled wholly by variation of engine speed.

In the equipments now ordered, however, the previous arrangement of off-load series/parallel switching and resistive field control for low speeds will be retained. English Electric will supply 121 of the equipments and 45 will come from G.E.C., so that one of the three firms who entered this field last year is again represented, and with a substantial increase over the 15 equipments of the earlier order. It may be recalled that a programme for the elimination of steam shunting power was announced by British Railways some time before publication of the modernisation plan. The speed with which it is being carried out is in marked contrast with the progress which has been made so far in finalising designs for main-line Diesel haulage.

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The Metallurgical Profession

The future prospects for metallurgy, and the attraction into the profession of young men, were foremost among the topics discussed by Mr. G. L. Bailey, C.B.E., director of the British Non-Ferrous Metals Research Association, in his presidential address to the Institution of Metallurgists in London on May 15. He said that it was not only necessary to see that would-be metallurgists were properly trained, but with the many competing fields of science open to them, it was necessary to tempt boys into the metallurgical profession. This the Institution had done, partly through its work with other bodies on the Joint Committee on Metallurgical Education, but mainly by arranging talks to careers masters and sixth-form schoolboys. A proposal which the Institution was trying to encourage among its employing members was particularly noteworthy. This was that sixth-form schoolboys be invited for a week or so into a metallurgical laboratory or works to enable them to see the interesting nature of the work carried out.

As in all branches of science, intellectual honesty was the first and basic consideration of the profession, Mr. Bailey said. In the future there would be plenty of room for all materials, metallic and non-metallic, but a choice would increasingly be made on the basis of detached judgment. It was all the more important, therefore, that the metallurgist should be relied upon to maintain that strict level of professional integrity that would retain the confidence of the public. Membership of the Institution provided a guarantee in this respect and it was important that this criterion be maintained.

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Wear and Seizure

Four years ago, Mr. G. De Lavalette told French automobile engineers of the improved resistance to wear and seizure which is imparted to steel and cast-iron surfaces by a sulphide-forming surface treatment known as S.A.T.S. "Sulf-Inuz." Several British firms became interested, and from practical trials—notably those on piston rings by Wellworthy Limited—it became evident that the new process had great possibilities. The Directorate of Aircraft Production Development, Ministry of Supply, have done much to encourage the study of this and other sulphurising treatments, and have helped a number of firms to achieve success in applications to bearing surfaces in many components, some of which function under conditions where normal lubricants could not be used. Imperial Chemical Industries, Limited, who have acquired the sole rights for

the process in the United Kingdom, gave an impressive demonstration at the 1954 Production Exhibition, using a Faville-Levally machine in which mild-steel bearing test specimens treated by the Cassel Sulfinuz process were run dry under increasing pressures; no seizure occurred although the specimens became red hot.

The article in this issue on "Reducing Wear and Frictional Resistance of Steel," by Mr. L. Marshall and Mr. S. J. Mansell, is the first publication of an independent scientific investigation of the properties of Sulfinuz treated surfaces. The experiments, particularly those with the Shell four-ball testing machine, are of great importance, since they afford an assessment of the improvement in wear/load characteristics, greater resistance to seizure, and the comparatively small rise in frictional resistance with increase in load. Naturally much additional research is required to establish more precisely the nature of the sulphide-rich layers, and to examine the effect which the treatment has on impact, tensile strength, fatigue and corrosion resistance. These aspects are being studied at the Metallurgy Department of the Battersea Polytechnic, some of the work being under contract from the Ministry of Supply.

It is of considerable interest to compare this and other sulphide-impregnating processes with the use of additives in extreme-pressure lubricants and cutting fluids. These additives also prevent seizure by the formation of surface films when local pressure and frictional heat are sufficiently high. The films are complex and may contain chlorides and phosphides in addition to sulphides. Probably the oil chemist can meet the challenge of sulphurising processes where normal lubricants may be applied, but in dry bearing conditions and at high temperatures the advantage may be with the Sulfinuz treatment.

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Rhodesian Steel

It was announced last week that the Lancashire Steel Corporation are sending two representatives to Southern Rhodesia to investigate proposals for expansion of the Iron and Steel Works at present operated by the Rhodesian Iron and Steel Commission at Redcliffe near Que Que. Proposals to expand these works have been under discussion between the Southern Rhodesian Government, the Messina (Transvaal) Development Company and the Lancashire Steel Corporation during the past year. It was originally suggested that the capacity of the blast furnaces at Redcliffe should be increased from the present figure of 50,000 tons of pig iron per annum to 200,000 tons per annum of which about 100,000 tons would be exported to the United Kingdom.

At present the blast furnaces at Redcliffe use coke produced at Wankie, but it has been proposed that coke ovens should be erected at Redcliffe which would involve the transport of about 200,000 tons of coal per annum from Wankie to Redcliffe. Owing to the recent rapid industrial expansion, the Rhodesian Railways have already been experiencing difficulty in distributing the total output of coal from the Wankie Colliery Company. Doubts have also been expressed regarding the ability of the railways to transport the pig iron for export. Although no official announcement has been made, it would seem probable that the emphasis in the initial stages is likely to be on expansion of the output of finished steel products and that additional blast furnaces and possibly coke ovens will be erected later.

Transport difficulties, however, are not likely to prevent for long the greater utilisation of the very large reserves of high grade iron ore (averaging 56 per cent.) and limestone in the neighbourhood of Redcliffe. In addition to this the Messina (Transvaal) Development Company have developed large reserves of 60 per cent. ore at Bukwe about 130 miles south-east of Que Que. It has been stated that costs are such as to permit the shipment of pig iron to the U.K. at competitive prices.

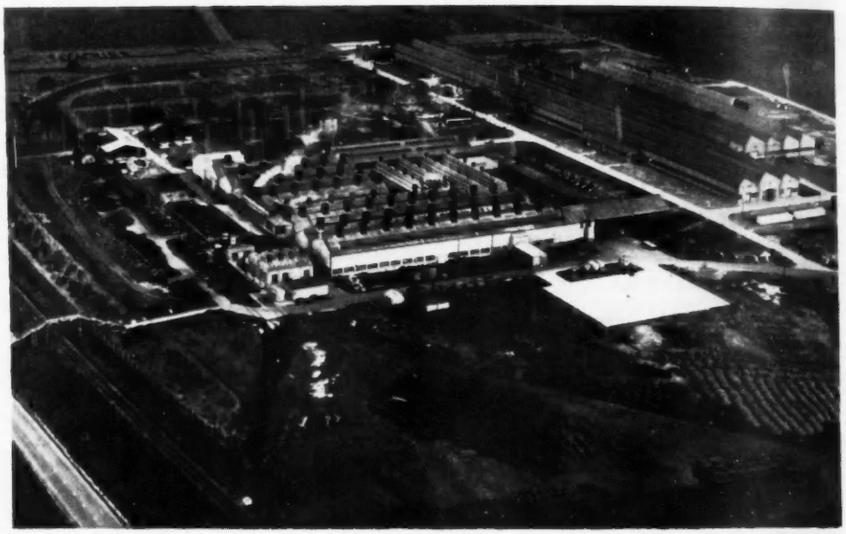
Farm Machinery Production

The increase in the use of farm machinery is reflected in the growth of Ransomes, Sims and Jefferies, Limited, Ipswich, whose payroll has now reached over 4,000. When it was realised some years ago that the Orwell Works were no longer large enough to satisfy future requirements, 266 acres of heathland were purchased at Nacton on the outskirts of Ipswich. Here, in 1948, the new foundry was opened (ENGINEERING, vol. 168, page 474, 1949) and to it other departments have gradually been added.

The company intend to transfer the whole of the Orwell Works to the new site, though the move is likely to take some time. The illustration reveals the present size of the works, which is noticeably larger than that shown in our columns seven years ago.

Production began in the new assembly and machine shops, called the "Plough Works," in January, 1955, and since then over 30,000 implements have been made there. The works have been laid out for flowline production and as much mechanical handling has been installed as is consistent with the variety of products that are being made. One of the main items of interest is the flow-coat painting line which has been introduced. It is believed to be the first of its size installed in England. The two assembly lines converge on it by means of a transfer conveyor, and the implements are carried through on a mono-rail endless conveyor system. Paint is sprayed on to them by jets from the floor and, if necessary, from the walls, and the excess drains back to a circulating pump. Using this method, only about one hundredth of the amount of paint is in circulation as would be required were the implements dipped into a static tank.

Another installation that has helped production and mechanised one of the former manual jobs is a group of machines for grinding and buffing the mould boards of ploughs. These boards are curved in two planes and previously were fed to the buffing wheel by an operator who tilted them as required to fit the shape. Now the tilting is carried out automatically on the machines which were built by W. H. A. Robertson & Co. Ltd., to the designs and requirements of Ransomes. Orders for similar machines have been received from the United States.



The new Nacton Works of Ransomes, Sims and Jefferies, Limited, to which the old Orwell Works are being transferred.

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Food Machinery

The manifold ramifications and technical complexities of the food machinery industry are apparent in the annual report for 1955 of the Food Machinery Association, which was issued last week. The Association has nine sections covering among other types of machinery, bakery and biscuit equipment, brewery equipment, confectionery, dairy equipment, canning, grain, mineral waters and packaging. The industry's connections with engineering are of two kinds. There is the direct connection in that many engaged in the industry are engineers and are concerned with the design and manufacture of machinery: there is also the fact that the Food Machinery Association is connected with a number of other associations, including the Dairy Engineers Association and the Mineral Water Engineers Association.

As an industry, its prospects are naturally exceedingly diverse. Its interests in bakery and biscuit equipment make it affected by the recent trend towards more varied and less standardised types of confectionery and more discriminate buying by the public; its nearness to the brewery trade makes it sigh with the brewers over the downward trend in beer consumption and smile expansively with those who have an interest in the booming soft drinks trade; its important stake in sugar confectionery, including chocolate, makes it sympathetic to the chocolate makers' recent troubles over the price of cocoa. Its interest in dairy equipment brings it close to important developments in stainless-steel production. Its dependence in part on the canning industry makes it sensitive to the prospects for supplies of steel strip; its propinquity to packaging and labelling brings it close to an industry which is making rapid strides with intricate machines and new plastics materials. All in all, to make machinery for food to-day, is to be at the forefront of technical development and to catch the puffs from most of the economic winds that blow.

Dependent as the industry must be on the purchasing power of the home market it is gratifying to note that exports are increasing. They have gone up by 30 per cent. in value between 1953 and 1955.

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Vision Recording on Tape

A new home—at Sunbury-on-Thames—and a new name—R.C.A. Great Britain Limited—make history in the development of this subsidiary company of the mighty Radio Corporation of America, R.C.A. Photophone Limited, as they were known until last week, were established in

1929 to develop and manufacture equipment for motion picture, sound recording and reproduction. The move to the large Sunbury-on-Thames factory suggests that the company are intent on rapid expansion. In addition to sound-recording equipment for cinemas they make a wide range of products including microphones, which are exported to the U.S.A. in large quantities, underwater detection apparatus, telemetering systems and domestic high-fidelity sound reproducers. They are also distributors of some of the parent company's products, such as electron microscopes, specialised electron tubes, television broadcasting and studio equipment, shipboard radio, aircraft radar, beverage inspection machines, metal detectors and other electronic devices. Several of these will probably be made here in due course, and the company are likely to become one of the largest makers of electronic equipment in the country.

The paper given recently to the Royal Society of Arts by Mr. C. G. Mayer, of the American R.C.A., showed that the company have made considerable strides in the recording of vision as well as that of sound. Mr. Mayer described a method of recording and storing colour and black and white television pictures which, though still experimental, holds out much promise and is a striking example of the application of electronics to photography. The equipment is similar in many respects to that used for sound broadcasting; it records the signals which the television receiver translates into images, in the form of impulses on a magnetic tape. The main difference lies in the magnitude of the quantities involved. Frequencies are generally higher than 3 million cycles a second, or more than 200 times the top frequency of sound recording. Magnetic heads for recording and reproduction have been developed with an upper frequency limit of about 3½ million cycles a second at a tape speed of 20 ft. a second.

Such developments are perhaps still far from the production stage, but the advantage of having access to the fruits of the American company's vast programme of research and development is valuable to the British company, and no less to this country.

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Computers on the March

The part electronic computers are expected to play in the mechanisation of office systems is discussed in the N.P.L. report " Wage Accounting by Electronic Computer " (H.M. Stationery Office, 2*s.* 6*d.*). The fact that the Government should recommend their installation in the offices of all organisations employing more than 5,000 people is a great tonic to those companies who have developed their manufacture. A new industry is being born which is the true child of the new industrial revolution, and one which, partly by its very nature, partly by its parentage, can be expected to grow quickly.

Two news items last week suggest that a widespread acceptance of computers in this country is expected. Standard Telephones and Cables, Limited, are taking over 50,000 sq. ft. of floor space in a five-storey building at Newport, Monmouthshire, to start manufacture. S.T. & C. have expressed their belief that this will open up a big new market both at home and for export. The British Tabulating Machine Company and the General Electric Company are to form a new jointly-owned company to design " competitively-priced computers and similar equipment for use particularly in the field of office machinery and automation." They expect collaboration in this field will lead to " significant advances in the development of these devices both in terms of design and engineering for production.

The significance of this move is that British companies are thinking in terms of volume production of machines which, until now, have been " hand-made " at very high cost. So far, only in the United States where International Business Machines have made nearly all the running, computers have been used mainly for research and demonstration purposes. It would seem that the prototype stage is now nearly over. There is little question that any machinery which, as the findings of the Government report show, can reduce office costs to less than a quarter of the present level will find many eager buyers even in organisations employing less than 5,000 people.

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Earnings of Continental Workers

Inflation is universally feared because it is felt that rising prices will mean a fall in living standards. The European Coal and Steel Community, faced with this problem on a six-nation scale, has carried out an intensive survey of the real wages of coal and steel workers in France, Germany, Italy and the Benelux countries.

International comparisons are difficult. One problem is the different level of social services in the six nations; another is the widespread provision of company houses, especially in the French coal industry. Some countries pay allowances that are properly a part of wages, and there are various kinds of payment in kind. The biggest problems, however, are the differences due to national tastes and habits. The Belgian worker, for example, spends twice as much on meat as the Dutch, while the Italian spends most on flour and bread. The Dutch pay most for housing and the Saarlanders spend most on entertainment and travel.

The compilers of the survey made up " national shopping baskets " on the basis of some 220 items of consumer goods and services after visiting over 2,000 shops and comparing 22,000 prices. Although they must necessarily be taken with certain reservations, the findings are extremely interesting for the light they throw on the standards of living of coal and steel workers. They can be summarised as follows. The best paid coal-miners, taking the living standards of a married underground worker without children, are the Saarlanders. Close behind come the Belgians, followed by the Dutch, French, German and Italian. For steel workers without children the position is that those of Luxembourg, which produces no coal, are much the best paid. They are followed by the Belgians, French, Germans, Saarlanders, Dutch and Italians.

Comparison with the real earnings of British coal and steel workers is not, of course, possible as the index used by the investigators is different from the index of retail prices. It is probably true to say that the British index contains a much wider range of items than the Community " shopping basket." This is particularly so of the durable consumer goods such as television sets and second-hand cars, which were not considered in the six-nation inquiry.

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Italian Sewing Machines

Italian industry has made its biggest post-war advances in light engineering. Three products have been outstanding—motor scooters, typewriters and sewing machines. The achievements of the first two are well known here and the reasons for their success can be judged at first hand. Italian sewing machines have not been imported in any large quantities and their success has escaped notice.

As with scooters and typewriters, success is due to good design, skilled workmanship and competitive prices. The limited range of the home market means that Italian light industry can only run on mass production lines if it captures export markets. This is exactly what the sewing machine firms have done. The industry is concentrated in Lombardy, particularly in and around the town of Pavia. The three biggest companies are Vittorio Necchi, Italian Singer, and Borletti, which together with about a dozen smaller companies produce nearly 500,000 machines a year. This figure is more than three times the 1938 level, though the annual rate of increase has now slackened off.

Italian housewives prefer the treadle type of machine, but the use of electric motors is increasing and they are fitted to most export models. Vittorio Necchi has achieved outstanding success by applying to the small household machines the " zig-zag " system which was formerly used only on their costly industrial models. This company now produces 18 different industrial and domestic types at the rate of 900 machines a day by modern assembly-line methods. So far as exports are concerned the results have been outstanding: 150,000 Italian sewing machines were exported last year, of which 90,000 went to the United States. At this rate sewing machines are one of Italy's best dollar earners.

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Unfair to Turbojets?

The virtues of the by-pass engine in economy and in absence of noise have been extolled by several speakers recently in the aeronautical field; in the opinion of Bristol Engines Limited, these virtues have been over-emphasised. We give below the substance of a statement issued by the Bristol Aeroplane Company, Limited.

" The basic facts of the jet versus by-pass controversy tend to be clouded by generalised, emotional and in some cases irrelevant issues. It is therefore worthwhile to state in the plainest terms the fundamentals involved. There is, however, a preliminary proposition that must be stated: any discussion of engine comparisons can be valid only if a common yardstick is used, e.g., thrust with thrust, weight with weight.

" *Size:* A jet engine of the same diameter as a by-pass engine will always produce the greater thrust. *Mass flow:* A jet engine of the same total mass flow as a by-pass engine will always produce the greater thrust. *Weight:* A jet engine will always be lighter than a by-pass engine of equivalent thrust. *Economy:* A jet engine will have the same, or a lower, cruising specific fuel consumption as a by-pass engine of equivalent thrust. *Cost:* A jet engine is cheaper to build than a by-pass engine of equivalent thrust. *Simplicity:* A jet engine will always be mechanically more simple than a by-pass engine of equivalent thrust. *Noise:* A jet engine will make the same volume of noise as a by-pass engine of equivalent thrust.

" From all these propositions it can be stated that if the diameter and mass flow of the engines are similar, then the jet engine will produce greater thrust than will the by-pass engine. And because it gives greater power it will therefore nominally burn more fuel: but if it is throttled back to give the same thrust as is produced by the by-pass, its specific fuel consumption will be the same as that of the by-pass, and possibly better. Conversely, for the same thrust, the jet engine will be smaller and lighter than the by-pass."

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New Geochemistry and Applied Geophysics Laboratories

While the argument about its major expansion plans proceeds, the Imperial College of Science and Technology has recently opened new laboratories for the study of Geochemistry and Applied Geophysics. By ingeniously building a mansard roof over the existing building of the Royal School of Mines, it has created a number of light, well-equipped rooms for instruction and research in these subjects.

In addition to a large laboratory for the chemical analysis of minerals, rocks and soils, there are laboratories devoted to spectrochemical analysis and to the study of trace elements. Of particular interest is the development of geochemical prospecting techniques which rely on the presence of significant traces of metals naturally dispersed in the rocks and soils around an ore body, in the vegation growing on these soils and the waters and sediments of streams. This method entails the search for " anomalies " in the natural distribution pattern of metals, using rapid methods of analysis of the minute

concentrations of metal involved. By virtue of its active interest in this field the Mining Geology Department of the College has become the headquarters in Britain for research in geochemical prospecting and is supported by the Colonial Office and D.S.I.R.

The Applied Geophysics Department provides instruction for undergraduates in the use of geophysics in the search for economic materials and at post-graduate level specialised training and, for those with suitable qualifications, a course of research leading to higher degrees.

In the electrical field, research is being conducted into the development of an induced polarisation method of detecting ore bodies. Seismic research is mainly concerned with details of the propagation of elastic waves through rocks. Two kinds of magnetic investigation are in hand; an academic study of the magnetic field of the geological past and the development of a mobile magnetometer for prospecting and other purposes.

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Training for the B.B.C.

Anyone working in a large organisation must work to greater effect if he is aware, at least in a general way, of its aims and the methods it uses to achieve them. This is especially true of a company or corporation based on some technology or science. Being aware of this, the British Broadcasting Corporation formed in 1945 their Engineering Training Department, with an establishment at Wood Norton near Evesham. The school now provides a wide range of courses not only for B.B.C. personnel but also for broadcasting staff from overseas.

Initial entry courses are held for newly-recruited technical assistants in the Operations and Maintenance Departments of the sound and television services and last for 12 weeks. Television operators have a six-weeks course on entering the B.B.C. Promotion courses also last for 12 weeks and deal with the principles of broadcasting and their application to B.B.C. equipment and practice. There is a similar 12-week course for technical operators in television; this includes camera operation, sound mixing, lighting and picture composition. Primarily for senior staff are the specialist courses which are of one to three weeks duration, and subjects range from fundamental principles to new developments; there is, for example, a one-week colour-television course. Finally there are conversion courses to qualify sound-service staff for transfer to television and workshop courses.

The establishment is extremely well equipped and includes for the sound side, an eight-position control room with studios, continuity and recording suites and a 7 kW transmitter; and for television, two complete camera channels, waveform generators and monitors and several studios. There are also a number of separate laboratories devoted to particular studies. In one, for example, all types of medium-wave, short-wave and v.h.f. aerials can be demonstrated showing propagation characteristics, directional properties and other features; there are model aerials working at a frequency of 150 Mc per second and 450 Mc per second. In the acoustics laboratory, the principles of wave motion in acoustic, optical and water systems can be illustrated, while wavelength characteristics are shown by means of a vibrating cord viewed stroboscopically. Interesting items in the optics laboratory are the "zoom" television lens which permits continuous viewing of objects rapidly approaching the camera or receding, and instruments for breaking up incident light into its constituent primaries.

These facilities have recently been supplemented by a new hostel building decorated in a pleasant contemporary manner, and there is now residential accommodation for some 200 students; it is expected that the number attending courses during 1956 will rise to more than 800. The policy of the B.B.C. to keep its employees, whether they be technically trained or not, in touch with the science they live by is a very wise one. Hence, though more profound engineering training is provided, an object of the school is to present highly technical information in such a way that advanced mathematical knowledge is not required.

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Electronic Test Equipment

New research and development laboratories for the Solartron Electronic Group, Limited, have recently been formally opened by Sir Walter Puckey at Goodwyns Place, Dorking, Surrey. The group has been built in eight years on the foundation of a number of small specialist companies and at present comprises Solartron Research and Development, Limited, and Solartron Electronic Business Machines, Limited, both of these companies being concerned with research and development activities; the manufacturing side comprises Solartron Laboratory Instruments, Limited, the oldest company of the group, formed in 1948, and specialising in batch-quantity production of electronic instruments, and Solartron Engineering, Limited, undertaking precision engineering mainly for the electronic and aircraft industries.

Since 1948, when the personnel numbered five, the group has made remarkable progress, while still remaining small. It now employs some 500 people. Sales and output have approximately doubled each year for the past five years and to-day the group claims to be one of the largest suppliers of electronic test equipment to the British market. Its principal lines of development comprise oscilloscopes and associated electronic equipment; servo test equipment for all types of controls; high-speed check weighers for the packaging of a wide range of commercial products; a tactical radar simulator for training ground controllers of aircraft; an electronic reading machine which will enable punched cards to be eliminated with certain types of computer; and "Eucrates," which comes near to being an electronic "brain" since it "forgets" and has "neurotic" characteristics. It is capable of making certain decisions and of being conditioned by an electronic trainer to respond in different ways to various stimuli.

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Railway Load and Electricity Supply

Sir John Dalton's statement (in his Presidential Address to the British Electrical Power Convention last week) that the increase in electricity consumption arising from the railway modernisation plan would only equal that due at the present time to the radio and television loads must have been a shock to those who regarded traction as a large prospective addition to the demand. He however gilded the pill a little by adding that this demand, being largely at night, would favourably affect the national load factor and the the Plan itself would provide employment for over 100,000 men per annum. Moreover, the decision of the British Transport Commission to adopt the single-phase 50 cycle system will have the important result of providing our manufacturers with useful experience in a new field and enable them to secure contracts in countries, such as Turkey and Portugal, where little or no electrification has so far taken place. Both British Railways and the British electrical industry should therefore benefit from the Plan and are, it is satisfactory to learn, closely collaborating in the development of the new system. Co-operation, and no doubt friendly rivalry too, is being continued with the French Railway Authorities, who are, of course, pioneers in this field.

It is worthy of record, too, that during the Convention the decision to abandon the well-tried direct-current system of electric traction as this country's standard was hardly challenged. It was realised, of course, that the electrification of trunk lines will not be without its difficulties—an illustration showing the track layout at Crewe was sufficient proof of this. It was realised, too, that there will be teething troubles, both on the supply side and with rolling stock, as well as differences of opinion as to how difficulties should be overcome. Brigadir. F. J. Lane and Mr. W. B. Noddings, representing the Central Electricity Authority, disclosed no pessimism about supply; and, though it would be foolish to be too sanguine about rolling stock, especially where the use of two voltages may be necessary, investigation and experience will doubtless lead to a solution. By using rectifiers and direct-current motors commutation difficulties should be overcome, and a chance provided to show overseas customers the advantages of a typical British compromise. In fact, the Convention, by recording what has been done, and still more what remains to be done, performed a useful function and the published proceedings will prove both a valuable account of past achievement and indication of future action.

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Rising Productivity in Chemicals

Since the war the chemical industry has been notable for its high rate of capital investment, and it would be expected that this policy of sustained modernisation of equipment would begin to show itself in the efficiency of the industry. One of the most interesting features of the directors' report of Imperial Chemical Industries, Limited, for 1955 is an index of output and wage costs which has been calculated for the years 1948 to 1955 inclusive. Despite the reduced profit margins on which the company has had to operate in the last year, there were indications that each unit of output continued to cost less in wages (including salaries). This is the kind of overall picture which would be expected from an industry which has maintained a high rate of capital investment despite severe competition in export markets.

Figures for the whole of British industry are not available for 1955 but between 1952 and 1954 the index calculated in the I.C.I. report for all industry, showing wages and salaries per unit of output, increased from 118 to 121 (taking 1948 as 100). Over the same period, I.C.I.'s index dropped from 116 to 100 and on to 99 in 1955. It is to be noticed that Monsanto Chemicals, Limited, whose directors' report for 1955 was published last week, speaks of "better yields and greater throughput," despite higher wages and other costs.

The critical issue for the industry, to judge from the I.C.I. report, is now the shortage of scientists and engineers. A chronic shortage of this kind could, of course, mean a serious slowing down in future mechanisation.

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Export Surplus Problem

It must be a pleasant predicament to be in to have an export surplus, but there are signs, however, that such is the problem for Western Germany. The latest credit restrictions there contain two provisions unfavourable to exports. Both these concern the favourable discount arrangements for commercial bills on exports, for these have now been taken away, and it may well be that their removal will be permanent. These moves follow a period of very high fixed investment in the German domestic market and a rapid rate of increase in the export of machinery of all kinds.

Point is given to this rapid expansion in the latest results published by the Allgemeine Elektricitats Gesellschaft group. This company increased its output by 25 per cent. in the financial year ended September 30, 1955, with a 15 per cent. increase in its labour force, an increase in efficiency which owes a good deal to a higher rate of capital investment by A.E.G. itself. It is interesting, however, that despite these indications of consistent competitive power and the important and increasing part which exports are playing in this group's success, export orders are becoming increasingly difficult to get although the heavy electrical industry's prospects in foreign markets continue to be bright.

REDUCING FRICTIONAL RESISTANCE AND WEAR OF STEEL

USE OF SULPHIDE-IMPREGNATED SURFACES

By *L. Marshall*, A.I.M., A.F.R.AE.S., A.I.MECH.E., A.M.I.PROD.E.* *and S. J. Mansell*†

In the autumn of 1953 the authors were asked to investigate the claims contained in Patent Specifications 640,536 and 692,287, published July 19, 1950, and June 3, 1953, respectively, covering " Improvements in and Relating to the Production of Wear Resistant Iron-Alloy Surfaces." The applicants were given as the Société d'Application des Traitments de Surface, 22 Rue Saint-Lo à Courbevoie (Seine), France.

Essentially, the process, which was initially designated as the S.A.T.S. process, is a method for the low-temperature heat treatment of ferrous alloys to obtain a high wear resistance. The wear-resistant layer is obtained by heating the ferrous alloy at a temperature within the range 550 to 600 deg. C. in a molten mixture of an alkaline cyanide, an alkaline cyanate, and an alkaline sulphide, the mixture containing at least 25 per cent. alkaline cyanide, sufficient alkaline cyanate to cause the mixture to melt at a temperature lower than 500 deg. C., and between 0·4 and 2 per cent. sulphur.

A mixture may be used, for example, of 95 per cent. sodium cyanide and 5 per cent. anhydrous sodium sulphite. The bath thus obtained will have the following composition: sodium cyanide (NaCN), 89·18 per cent.; sodium cyanate (NaCNO), 7·73 per cent.; sodium sulphide, (Na_2S), 3·09 per cent. The bath contains 1·27 per cent. of active sulphur. The required composition is achieved since the two molten salts, sodium cyanide and sodium sulphite (Na_2SO_3) react according to the equation

$$Na_2SO_3 + 3\,NaCN \rightleftarrows 3\,NaCNO + Na_2S.$$

The wear-resistant layer is probably due to the formation of sulphides, mainly iron sulphide.

Lacking accurate information on the frictional and wear-resistant properties of the sulphide films formed on steels by the S.A.T.S. process, an attempt was made to evaluate these by means of a conventional coefficient-of-friction apparatus using a sliding weight drawn over a plane. The results obtained were inconclusive and further work in this direction was abandoned.

Two possibilities remained, either to build a special friction-testing machine, or to make use of some form of existing lubricant-testing machine, such as the Shell four-ball machine or the Faville-Levally machine which had been used by the originators of the process.

Since the Shell four-ball machine looked as though it might offer a more quantitative assessment of the wear resistance of the sulphide film, as well as of its frictional properties, it was decided to make initial tests using this machine. Later, when the efficacy of the process had been established and it was necessary to ring the changes on the types of steel treated, use was made of the Faville-Levally machine.

TESTS WITH THE SHELL FOUR-BALL MACHINE

The immediate purpose of the tests carried out on this machine was to determine the effect of the S.A.T.S. process on the surface condition of steel balls. The principal factors to be evaluated were the wear/load, including seizure/load, characteristics, and frictional properties.

The steel balls used for this series of tests were in the following condition: (*a*) original hardened and polished state (as supplied by the manufacturers of the machine); (*b*) heat-treated for 1½ hours at 570 deg. C. and left unpolished; (*c*) treated by the S.A.T.S. process for 1½ hours at 570 deg. C. and left unpolished. The purpose of the treatment in group (*b*) was to obtain a set of balls for comparison having the same metallurgical structure as the S.A.T.S.-treated balls. The nominal composition of the balls was given as: carbon, 1 per cent.; manganese, 0·35 per cent.; silicon, 0·30 per cent.; chromium, 1·50 per cent.; phosphorus, 0·025 per cent. maximum; sulphur, 0·025 per cent. maximum.

All tests were made using D.T.D.585 mineral-base hydraulic fluid as a lubricant.

The machine, as is shown in Fig. 1, consists essentially of a chuck B holding a ½ in. diameter steel ball, which is rotated at a constant speed by an electric motor A in a cavity formed by three other balls clamped in a cup C which holds the lubricant. The test element without the cup and chuck is shown in Fig. 2. The load is applied to the balls by a pivoted lever E, producing a frictional torque when the machine is in operation. The displacement of an indicator bar D attached to the top of the cup is recorded on a chart placed on a constant-speed drum F. This displacement is directly proportional to the frictional torque produced.

As the upper ball is rotated, " wear scars " appear and these can be measured on completion of the test run by means of a calibrated microscope. The friction between the balls will also produce a rise in temperature of the lubricant which can be measured.

The apparatus was assembled with a new set of four balls for each determination, and after the load had been applied, the upper ball was rotated for 60 seconds. The rise in temperature of the fluid was noted and the scar diameter measured in two directions at right angles on each of the three lower balls. The mean scar diameter was determined from these six values.

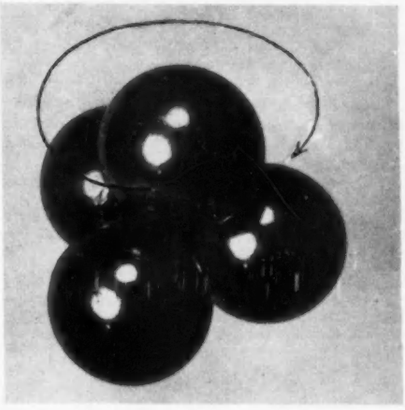

Fig. 2 Test element of Shell four-ball machine.

For each of the three types of ball, the tests were repeated a number of times with varying loads, and the load for which total seizure took place was determined. From each individual test, values for mean " wear scar " diameter, coefficient of friction, and rise in temperature of the lubricant were obtained. From these values graphs for load against wear, rise in temperature and coefficient of friction were drawn for all three types of ball.

The indentation due to static loading was determined using the equation of Appendix I which gives a theoretical value for the Hertz diameter. The value of d_h, the diameter of the contact area, may also be determined by actual measurement using a staining technique.

If log d_h is plotted against log P, a straight line will be obtained, known as the Hertz line; it represents the elastic deflection of the balls under the various applied loads, and may also be considered as the ideal condition if no indentation due to wear took place. A graph of the log of the " wear scar " diameter against the log of the applied load will demonstrate how the wear/load curve deviates from the Hertz line.

It was suspected that the Young's modulus of the steel would be affected by heat treatment and therefore the Hertz line for the original balls would not coincide with that for the heat-treated and S.A.T.S.-treated balls. The diameter of contact area was measured for two values of load on each of the three types of ball. As Young's modulus was known for the balls in their original state, a theoretical Hertz line was obtained and the measured values for the heat-treated and S.A.T.S.-treated balls were found to be identical, but did not coincide with those of the original balls. The lines lay approximately parallel with the former, showing larger contact area diameters for the same load than the original balls.

IMPROVED WEAR/LOAD, SEIZURE AND FRICTIONAL CHARACTERISTICS

The wear/load curve for the balls in the original state follows the average trend as shown by balls tested in mineral oils, but the total

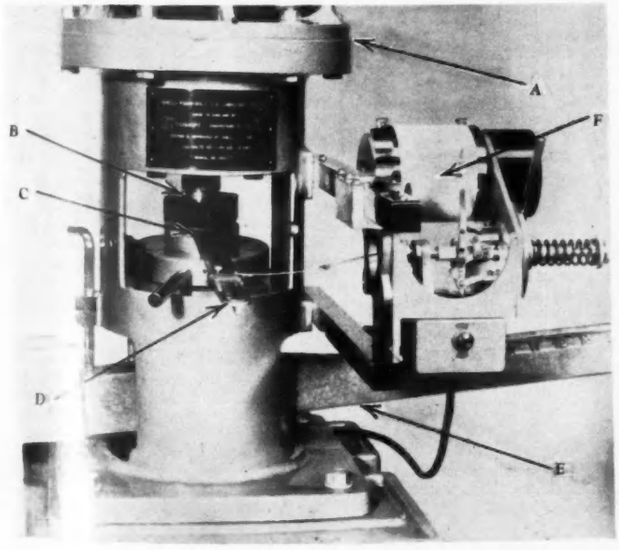

Fig. 1 The Shell four-ball lubricant-testing machine of which the test element comprises balls arranged as in Fig. 2. The crown ball, held in a chuck, is rotated in the cavity of the other three. By using different balls, some with sulphide-impregnated surfaces, and measuring wear and friction under test, surface-treatment characteristics were determined.

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† Senior Chemist, Electro-Hydraulics Ltd.

seizure load is increased in the case of D.T.D. 585 hydraulic fluid since it contains a small percentage of tricresyl phosphate, a chemical known to improve the extreme pressure properties of oils. (Fig. 3).

The wear/load curve for the heat-treated balls was somewhat similar in shape, but up to approximately 50 kg. showed a higher wear-scar value than the original polished balls. The different Hertz lines may partly account for this. However, above this load up to seizure, the "wear scar" diameters were less than those for the original balls. That the increased efficiency under higher loading gives less wear and a higher seizure load may be attributed to the thin layer of oxide on the heat-treated balls tending to act as a lubricant.

The wear/load curve for the S.A.T.S.-treated balls showed that the treatment had greatly reduced the wear for loads above 20 kg., but at 20 kg. the wear was again slightly greater than for the original balls. The curve is noteworthy in that it follows the Hertz line closely and the load at which total seizure took place was increased by approximately 250 kg.

Fig. 4 shows the graph for coefficient of friction plotted against load. This shows that the frictional forces between the heat-treated balls are somewhat less than those between the polished balls for higher values of load. This was probably due to the combined effect of oxide and oil producing a film which was more efficient in reducing friction than oil alone.

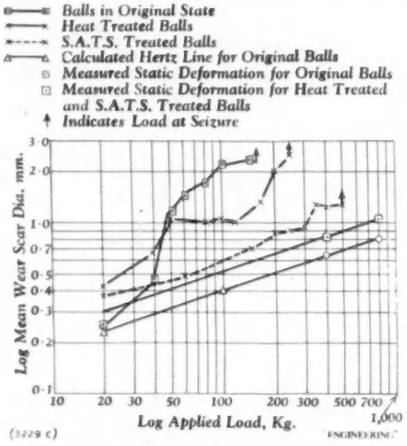

Fig. 3 Wear/load curves and Hertz lines.

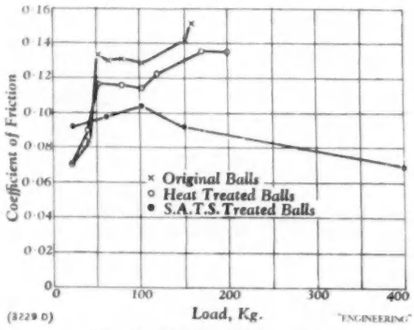

Fig. 4 Friction/load curves.

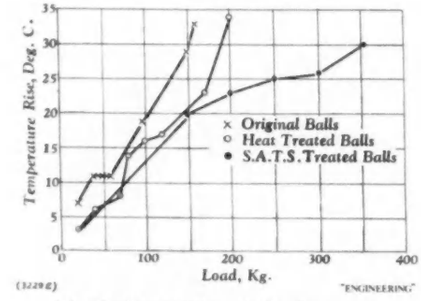

Fig. 5 Temperature-rise/load curves.

Figs. 3, 4 and 5. Data for these graphs came from tests on a Shell four-ball machine.

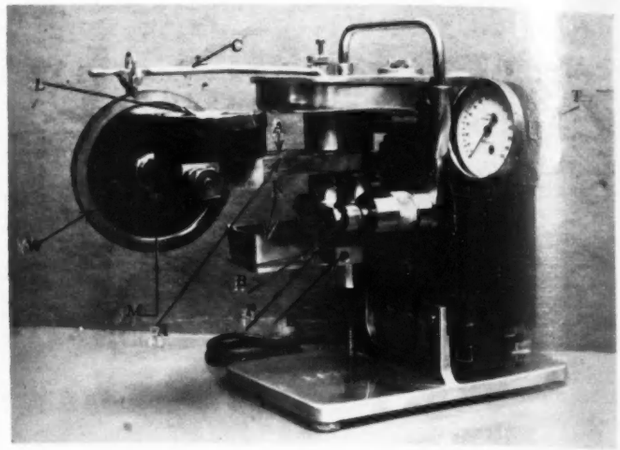

Fig. 6 The Faville-Levally lubricant testing machine which was was also used to determine the characteristics of steels with different surface treatments.

In the case of the polished and heat-treated balls, for loads of 50 kg. and above, the value of the coefficient of friction was determined after incipient seizure had taken place and the lubricating film had been re-established giving a fairly constant coefficient of friction for the remainder of the run.

The rise in temperature of the balls and lubricant during a 60 secs. run is proportional to the work done due to friction between the balls, and is therefore equivalent to the average frictional torque produced.

Fig. 5, showing temperature rise against load shows that considerably less heat was generated, between the S.A.T.S.-treated balls than for the original or heat-treated balls.

Thus it would appear from these results that the S.A.T.S. metallic-salts treatment improves wear/load characteristics, increases the load at which seizure takes place, and reduces the frictional resistance for the specific test conditions considered.

SULFINUZ TREATMENT; TESTS ON THE FAVILLE-LEVALLY MACHINE

At this stage in the investigations the authors were informed that the rights for operating the S.A.T.S. process in the United Kingdom had been taken over by a well-known organisation and marketed under the trade name "Sulfinuz." A small salt-bath was installed to operate the process and all subsequent treatment was carried out in this bath.

The purpose of the tests carried out on the Faville-Levally machine was to compare results with those obtained on the Shell four-ball machine and to obtain the wear/load and seizure/load characteristics on specific engineering steels after treatment in the Sulfinuz bath. In this machine the test specimens consist of two V-shaped bearing blocks and a pin which rotates between them. By means of an inching device the load exerted on the pins is progressively increased. Sets of V-blocks and pins to the following chemical composition were supplied with the machine and were used for the tests.

Pin: C, 0·38 per cent.; Mn, 0·78 per cent.; Cr, 0·62 per cent.; Ni, 1·18 per cent.; Mo, nil; Si, 0·22 per cent.;

V-block: C, 0·38 per cent.; Mn, 1·45 per cent.; Cr, 0·02 per cent; Ni, 0·03 per cent.; Mo, nil; Si, 0·02 per cent.

Three groups of test pieces were treated in the sulphinisation bath for 1 hour, 1½ hours, and for 2 hours, respectively. Each group was divided into two sets, one being tested dry, and one lubricated using a light mineral oil. Sets of test pieces in the untreated condition were tested under similar conditions.

The Faville-Levally machine is illustrated in Fig. 6, above. A pin P is rotated between two V-shaped blocks B which are normally immersed in an oil cup R containing 55 c.c. of lubricant. The blocks are inserted in self-aligning recesses in the short lever arms, or jaws of the load-applying mechanism. The pressure is applied through the loading mechanism M, W, and L which fits loosely over the bifurcated end of the long lever arm A. The ratchet wheel W is turned by hand until the loading mechanism takes hold, which is indicated by the registration of applied load on gauge L. Additional load is applied by engaging the load-applying arm C with ratchet wheel W. The eccentric motion

TABLE I.—Load Corrected for Block-Angle Variation

Treatment	*Test conditions*	*Block angle*	*½ Block angle θ*	*Maximum indicated load, lb.*	*Corrected maximum load, lb.*	*Maximum torque, lb.-in.*	*Remarks*
Untreated ..	Dry	Deg. min. 95 45	Deg. min. 47 52½	500	477	21	Seized, considerable wear took place.
Untreated ..	Oil	95 45	47 52½	1,200	1,144	30	Seized, considerable wear took place.
1 hour "Sulfinuz" ..	Dry	95 30	47 45	2,500	2,389	90	Pin became red hot and started to extrude through the block. No seizure.
1 hour "Sulfinuz" ..	Oil	96 0	48 0	4,500	4,282	77	*Maximum load for machine* No seizure occurred.
1½ hours "Sulfinuz" ..	Dry	96 0	48 0	2,250	2,141	79	Pin became red hot and started to extrude through the block. No seizure.
1½ hours "Sulfinuz" ..	Oil	96 30	48 15	4,500	4,265	75	*Maximum load for machine* No seizure occurred.
2 hours "Sulfinuz" ..	Dry	95 40	47 50	2,250	2,147	89	Pin became red hot and started to extrude through the block. No seizure.
2 hours "Sulfinuz" ..	Oil	96 0	48 0	4,500	4,282	75	*Maximum load for machine* No seizure occurred.

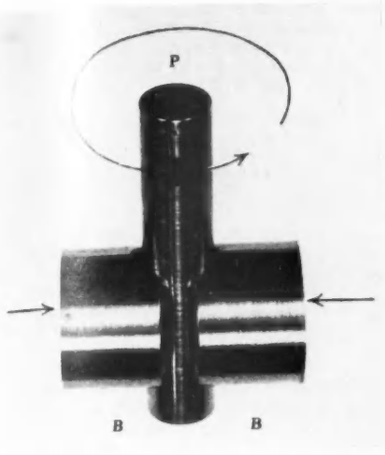

Fig. 7 Test element of the Faville-Levally machine.

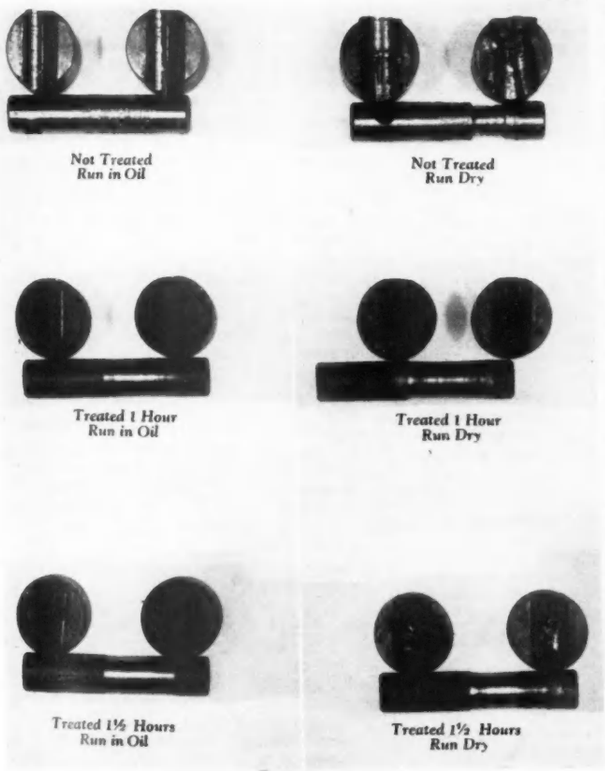
Not Treated Run in Oil
Not Treated Run Dry
Treated 1 Hour Run in Oil
Treated 1 Hour Run Dry
Treated 1½ Hours Run in Oil
Treated 1½ Hours Run Dry

Fig. 8 Faville-Levally test pieces after the test run.

of the load-applying arm C increases the application of the load one tooth at a time. The action is similar to that of a mechanically-operated nut cracker. The entire mechanism is free to swing about its axis, this tendency to turn being resisted by a sylphon-operated gauge T which registers torque in lb.-in.

In all lubricant testing machines of the extreme-pressure type there are usually variables which may influence the test results. These must be standardized in order to obtain reproducible results. With the Faville-Levally machine these are the block angle and the surface finish of the bearing area of the V-blocks.

In order to check the block angle, all blocks used were projected and measured on a tool-room projector. These values are quoted in Table I. The complete test element is shown in Fig. 7. The figures corresponding to the angles of the various blocks used were calculated for each load observation and the true load obtained in each case. Final values are also given in Table I.

Photographs of the various specimens after completion of their test run on the Faville-Levally machine are shown in Fig. 8.

RESISTANCE TO SEIZURE OF TREATED SPECIMENS

On completion of the torque/applied-load graphs for this series of tests, the following conclusions were deduced :—

1. *Test Pieces Run Dry* (Fig. 9).—In proportion to the applied load the torque decreased slightly with length of Sulfinuz treatment for loads up to 1,830 lb. For loads greater than 1,830 lb., lower torque results in proportion to the applied load were obtained on the test pieces Sulfinuz treated for 1½ hours. The untreated test pieces seized at a load of 477 lb. No seizure of the Sulfinuz treated test pieces occurred.

2. *Test Pieces Run in a Light Mineral Oil* (Fig. 10).—In proportion to the applied load, similar torque results were obtained for loads up to 2,000 lb. For loads greater than 2,000 lb., the lower torque results were obtained on the test pieces Sulfinuz treated for 1½ hours. The untreated test pieces seized at a load of 1,144 lb. No seizure of the Sulfinuz treated test pieces occurred.

These results show clearly the advantages to be derived from the sulphinisation treatment in terms of increased wear resistance, lower running friction, and ability to cope with loads normally sufficient to cause incipient seizure. The best practical results appear to be derived from the 1½ hour treatment.

PRACTICAL APPLICATIONS

The authors are aware of a number of cases where the use of sulphide-treated steel components has greatly facilitated the production of engineering units. A typical case was a gear pump which had been found extremely difficult to seal on the main drive shaft. The usual procedure was to finish the rotating steel-to-steel face seal to a near Johannson block finish. Even this was no guarantee that the pumps would pass bench-running tests without seizure on being run up to their working pressure.

It was found possible, using a lower-grade surface finish and Sulfinuz treatment of the seals, to increase significantly the number of passes obtained on the bench test.

The process has also been used for the treatment of small tools, such as reamers, with considerably increased life and retention of dimensional accuracy.

NATURE OF THE SULPHIDE FILM

It has been shown by microscopical examination of Sulfinuz-treated steels that the sulphur-rich layer formed by the process penetrates to a depth of approximately one-thousandth of an inch, and is backed by a nitrogen-containing layer which varies considerably in depth according to the alloy content of the steel. In the case of mild steel the nitrogen-containing layer may penetrate to a depth of 0·08 in. as shown by the presence of " nitride needles " in the structure, whereas with a high-alloy steel such as S80 martensitic stainless steel the nitriding effect is more compact and is usually only 0·002–0·003 in. deep. A photomicrograph of this steel after Sulfinuz treatment (Fig. 11) shows clearly the two zones.

Probably the real reason for the effectiveness of the Sulfinuz film lies in its dual nature, i.e., its naturally lubricated surface backed by a relatively hard-nitrided supporting layer.

In thanking the directors of Electro-Hydraulics Limited for permission to publish this paper, we also wish to express our sincere appreciation of the co-operation and advice given to the authors at all stages of the work by Messrs. Fletcher Miller Limited.

As regards the Sulfinuz process we are indebted to Imperial Chemical Industries, Heat-Treatment Department, Oldbury, for their advice on the operation and control of the process, and for the kindly interest they have shown in the progress of our experiments.

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APPENDIX 1

Mathematics of the Shell Four-Ball Machine

The four balls in the apparatus are arranged in the form of an equilaterial tetrahedron so that the vertical load P produces an oblique force P_1 between the top ball and each of the three lower balls, as shown in Fig. 12.

Since the angles in an equilateral tetrahedron are equal, the magnitudes of the forces may be

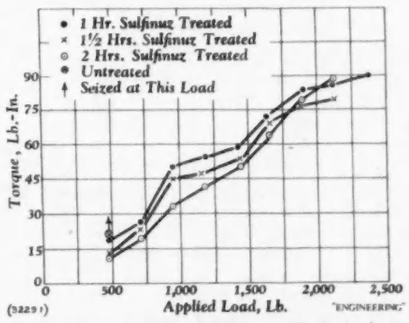

Fig. 9 Torque/applied-load curves for test pieces run dry on Faville-Levally machine. Seizure of untreated pieces occurred at a load of 477 lb.

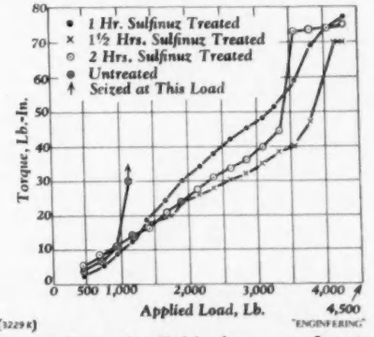

Fig. 10 Torque/applied-load curves for test pieces run in oil on Faville-Levally machine. Seizure of untreated pieces occurred at an applied load of 1,144 lb.

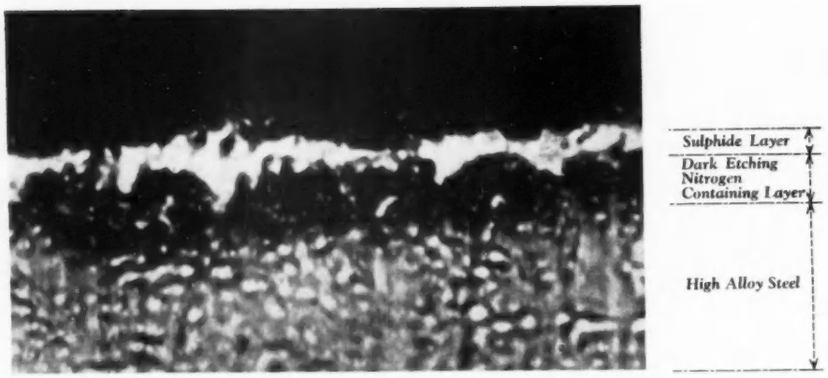

Fig. 11 Photomicrograph X2800 of sulphide and nitrogen-containing layers of Sulfinuz-treated surface. The depth of the nitriding effect is of the order of 0·003 in.

represented by dimensions of the tetrahedron, as shown in Fig. 13. Thus, if

$$AB = DB = CB = DC = AD = AC = P_1$$

then

$$AM = BM = \frac{\sqrt{3}}{2} P_1, \quad OM = \frac{\sqrt{3}}{6} P_1,$$

and

$$BO = \frac{\sqrt{6}}{3} P_1.$$

The resultant vertical force due to the three balls is $3\,BO = \sqrt{6}\,P_1$ and is this equal to the applied load P.

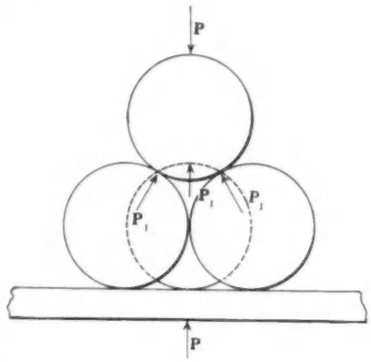

Fig. 12 Diagrammatic sketch of the four-ball test element, indicating the forces involved. The resultant deformation of the balls is found by using Hertz's formula.

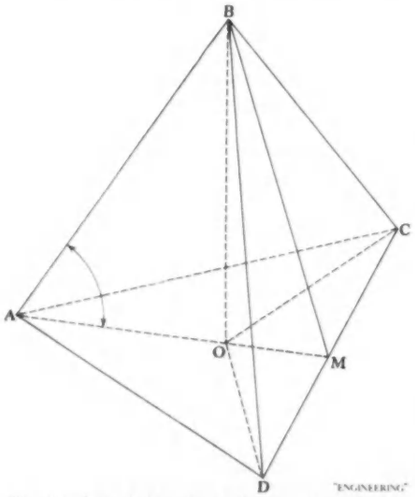

Fig. 13 Tetrahedron force diagram corresponding to the four-ball testing machine.

Therefore

$$P_1 = \frac{P}{\sqrt{6}} = 0{\cdot}408\ P. \quad . \quad (1)$$

Static Deformation of Balls under Load

For the purpose of this test, it was necessary to know the static indentation, expressed in terms of the diameter of the contact area, caused by deformation under load. This is known as the Hertz diameter.

According to Hertz, the radius of the contact area between two spherical surfaces may be expressed as follows:

$$a = \sqrt[3]{\frac{3\pi}{4} P_1 \frac{(k_1 + k_2)\, R_1 R_2}{R_1 + R_2}} \quad . \quad (2)$$

where a = radius of contact area, P_1 = applied compressive force, R_1 and R_2 = radii of the two spherical bodies, and k_1 and k_2 are constants involving Poisson's ratio and Young's modulus.

When both spheres have the same elastic properties, as is the case with the four-ball machine, equation (2) may be expressed in the following form:

$$a = 1{\cdot}109 \sqrt[3]{\frac{P_1}{E} \frac{R_1 R_2}{R_1 + R_2}} \quad . \quad (3)$$

where E is Young's modulus. This assumes a value of 0·3 for Poisson's ratio.

Since the balls in the four-ball machine contact at an angle to the vertical force, and since all four balls have the same radius, equation (3) becomes:

$$a = 1{\cdot}109 \sqrt[3]{\frac{P_1}{E} \frac{R^2}{2R}} = 1{\cdot}109 \sqrt[3]{\frac{P}{\sqrt{6}\,E} \frac{R^2}{2R}}. \quad . \quad . \quad . \quad . \quad (4)$$

If E is given the value $2{\cdot}10 \times 10^6$ kg. per sq. cm., and R is 0·635 cm.:

$$a = 4{\cdot}38 \times 10^{-3} \sqrt[3]{P} \text{ centimetres} \quad (5)$$

so that the diameter of the contact area, d_h (= 2a), becomes:

$$d_h = 8{\cdot}76 \times 10^{-2} \sqrt[3]{P} \text{ millimetres}. \quad (6)$$

Coefficient of Friction

The frictional torque exerted on the lower balls may be expressed as follows:

$$T = f \times \frac{3P}{\sqrt{6}} r \text{ kg.-mm.} \quad . \quad (7)$$

where T = the frictional torque kg.-mm., f = coefficient of friction, P = ap[illegible] load in kg., r = radius, and is the distan[illegible] from the centre of the contact surfaces of the [illegible]derlying balls to the axis of rotation, 3·67 mm.

Also

$$T = FL \text{ kg.-mm.}$$

where F = force in kilograms exerted on the indicator spring and L = length in millimetres of the torque lever arm.

Therefore

$$f = \frac{\sqrt{6}\,FL}{3\,Pr} \quad . \quad . \quad . \quad (8)$$

$$f = \frac{0{\cdot}222\,FL}{P} \quad . \quad . \quad . \quad (9)$$

APPENDIX 2

Mathematics of the Faville-Levally Machine

The mechanics of the machine are shown in Fig. 14 and, together with the mathematical explanation given below, attention is drawn to the importance of standardisation of the V-block angles.

Force is applied to the surfaces of the V-blocks by the long arm A (Fig. 6) through a lever where the resistance arm is situated between the fulcrum and the effort arm.

The manufacturer supplies the machine with the load gauge calibrated to read directly in the total force on the bearing faces. This is $(F_2 + F_3)$ when the block angle is 90 deg. Under these conditions, each lb. of load applied to the spring in gauge L exerts a force of 13·08 lb. on the bearing faces and registers this force on the dial of the load gauge. This arrangement produces a load-gauge reading of 13·08 lb. regardless of the magnitude of the block angle. Therefore, when the block angle varies, the total force on the block face will also vary, but the load gauge will remain constant and introduce an error into the measurements.

Referring to Fig. 14, it can be seen that

$$F_1 = \frac{8{\cdot}093\,L}{0{\cdot}875} = 9{\cdot}249\,L = \text{force on pin};$$

$F_2 + F_3$ = force on bearing faces = G (gauge reading);

$$\sin\theta = \frac{\frac{1}{2}F_1}{F_2} = \frac{F_1}{2F_2} = \frac{F_1}{F_2 + F_3} = \frac{9{\cdot}249\,L}{G};$$

and

$$G = \frac{9{\cdot}249\,L}{\sin\theta}.$$

With 90 deg. block angles (θ = 45 deg.) and L = 1 lb.,

$$G = \frac{9{\cdot}249 \times 1}{\sin 45 \text{ deg.}} = \frac{9{\cdot}249}{0{\cdot}7071} = 13{\cdot}08 \text{ lb.}$$

If $F_2 + F_3$ = applied load (on bearing faces),

then

$$\sin\theta = \frac{F_1}{F_2 + F_3} = \frac{F_1}{\text{applied load}}$$

so that

$$\text{applied load} = \frac{F_1}{\sin\theta}$$

and

$$G = \frac{9{\cdot}249\,L}{\sin 45 \text{ deg.}} = \frac{F_1}{0{\cdot}7071} \quad \text{and} \quad F_1 = 0{\cdot}7071\,G.$$

Then, for blocks of any magnitude

$$\text{the applied load} = \frac{0{\cdot}7071\,G}{\sin\theta}.$$

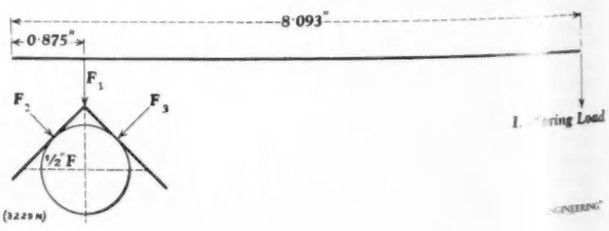

Fig. 14 Diagrammatic arrangement of the Faville-Levally machine, illustrating the mechanics involved.

ELECTRICITY AND TRANSPORT

BRITISH ELECTRICAL POWER CONVENTION

The eighth British Electrical Power Convention opened at Torquay on Wednesday, May 23, and closed on Tuesday, May 29, the president being Sir John Dalton. For the first time the example of the British Association was followed and the meeting was divided into two parts by a week-end, a precedent which we are glad to learn is not to be repeated next year. The 38 organisations which form the constituent membership of the Convention were all represented, and the official attendance numbered over two thousand.

The theme of the Convention this year was "Electricity and Transport," a subject which was dealt with in nine papers covering the various aspects of railway electrification and also road vehicles. In addition, there was one paper on "The Electric House."

As on previous occasions, a feature of the Convention was an exhibition of technical and domestic appliances which covered an area of some 34,000 sq. ft. on the Torre Abbey Meadows, and in which about 90 firms participated.

PRESIDENTIAL ADDRESS

It was particularly apposite, said the President, that the subject of this year's Convention should be "Electricity and Transport," as the adoption of the single phase 50 cycle system by the British Transport Commission would present certain problems to the power supply engineer. The industry, too, was a partner in the imaginative plan of electrification which would, it was to be hoped, rehabilitate the country's railway system.

It was estimated that the new proposals would lead to an increase in the annual consumption of the British Transport Commission of 1,500 million kilowatt-hours, which would be a useful contribution to the national output, particularly as most of it would occur at night. Nevertheless, this first instalment was unlikely to have any material effect on the national load curve, since by 1960 the consumption for traction purposes would not be more than 3½ per cent. of the total and was not likely to be more than 2½ per cent. in 1971.

On the other hand, the present consumption for domestic space heating was 6,500 million kWh. per annum, for cookers 4,550 million kWh., for domestic water heating, 2,500 million kWh., for television 990 million kWh. and for radio 510 million kWh. These figures were not given to detract from the benefits which must flow from the railway plan, but to show that the electrical industry could without difficulty give every assistance to transport when it was decided to extend the present plan for electrification.

A recurring electrical problem was the restriction of capital investment placed primarily on the Central Electricity Authority, but which reflected on the whole economy of the industry. For 1956–57, the "normal" programme of the Authority and the Area Boards had been reduced from £213 to £195 million. The result must be a falling off of 500 MW in the plant commissioned in 1958–59, and a partial disorganisation of manufacturing production generally. The effect on the distribution programme of the Area Boards must also be serious. In fact, the result would be that the day when the Central Electricity Authority could meet all demands without load shedding or voltage reduction would have to be postponed, and it would become more difficult to perform its other functions as a servicing industry.

ELECTRICITY IN RAIL TRANSPORTATION

At a meeting in the Pavilion on Friday morning, May 25, papers on "Electricity in Rail Transportation," by Mr. S. B. Warder, and on "Electricity Supply and the Railway Load," by Messrs. F. J. Lane and W. B. Noddings, were presented for discussion.

Mr. Warder introduced his paper by recording how slow had been the infiltration into the railways of the art of the electrical engineer, especially in this country. The impact of various developments was also described as well as the part they had played in the merging of the best features of the alternating and direct-current systems into the new form of electric traction which had now been adopted as standard on British Railways.

During 1953 the electricity consumption of the British Transport Commission amounted to some 2,210 million kilowatt-hours, of which 1,666 million kilowatt-hours were for traction purposes. The Commission should for many years be contributing blocks of load to the Authority, which should be attractive, owing to the fact that a large proportion should occur outside normal peak hours. The present proposed extensions of electric traction, amounting to 1,430 miles, would increase the annual consumption by 1,488 million kilowatt-hours, making a total of 3,697 million kilowatt-hours to which must be added the increasing demand due to the modernisation of installations.

A CASE FOR ADOPTION

Turning to the new system of electrification, Mr. Warder said that the case for the adoption of the 25 kV, 50 cycle system was clearly established under the headings of power supply, overhead equipment and motive power. Financially, too, it was superior, both as regards first and running cost.

The report issued by the British Transport Commission in 1951 pointed out that the traffic density which would justify electrification lay between three and four million trailing ton-miles per annum per mile of single track; and it was estimated that this density existed, or was exceeded, on 5,500 miles out of a total of 18,000 route miles. It was therefore reasonable to forecast an ultimate prospective economy of £100 million by adopting the alternating-current system, assuming that 75 per cent. of the further economies that seemed potentially possible were realised on the single track mileage on which the traffic density exceeded three million ton-miles in 1949.

Intimate knowledge was, however, needed before it could be said that a system which was good for one country was good for another. If the railways of a country were already electrified a change of system would hardly be justified. On the other hand, it was not without significance that railways where there had been little or no electrification had opted for the 50 cycle system during the past two or three years, Turkey and Portugal being cases in point.

A GAIN FOR INDUSTRY

As the 50 cycle system was comparatively young, considerable development and simplification of it should be possible, and both British Railways and the electrical manufacturing industry should stand to gain from the closest collaboration in these fields. The manufacturers had welcomed the decision to adopt the alternating-current system and had agreed to interchange ideas both with the Commission and with each other. They would endeavour to achieve as much standardisation as practicable and would accelerate developments and have prototypes ready as quickly as possible. There was thus a unique opportunity to avoid wasteful competition and duplication of effort.

SINGLE-PHASE RAILWAY LOAD

In their paper on "Electricity Supply and the Railway Load," Messrs. F. J. Lane and W. B. Noddings said that where there was a substantial high-voltage grid system the cost of providing 25 kV supplies from the point of the tee-off to the railway track switchboard was £13 per kVA of firm capacity, compared with £18 per kVA for providing supplies at the direct-current busbars of track substations. As in the latter case it also would be necessary to provide for more points of supply, the total cost of the direct-current system would be nearly three times that of alternating current.

The main effect on the public electricity system of supplying large single-phase loads was to cause unbalanced voltages at the points of supply, thus affecting the voltage to other consumers and restricting the capacity of the network. The degree of out-of-balance depended on the point on the system at which supplies were taken, and the lower the short-circuit level the greater the effect, the coefficient of asymmetry being about the ratio of single phase load to short-circuit power. In the opinion of French engineers this coefficient should not exceed 5 per cent. It could be relieved by the use of Scott-connected transformers or by single-phase transformers connected between alternative phases throughout the railway system. The latter was the better arrangement since the single-phase loads would tend to balance each other. The effect of unbalanced load on generators was not likely to be serious.

The interest of the electricity supply authorities in the choice of locomotives lay in the power factor and the effective harmonics generated. Higher power factors would be obtained with the direct-current drive, and it was thus to be preferred. The effect on the system of harmonics generated by single-phase rectification differed little from those generated by three-phase rectification, provided the third harmonic was suppressed. Moreover, the effect was related to the coefficient of asymmetry at the point of supply, and interference would therefore be less with supplies taken direct from the 132 kV system.

FUTURE PROSPECTS

As regards the magnitude of the future railway load the consumption of existing systems was not a suitable basis of estimation. An average consumption of 60 watt-hours per trailing ton mile had been suggested, amounting to 3,300 to 3,600 million kWh per year if the electrification envisaged in the Cock report were carried out. At 50 per cent. load factor the maximum demand would be between 750 and 820 MW. The British Transport Commission estimated that their proposals would call for a total demand of 320 MW at 53 per cent. load factor, but individual parts of the scheme were estimated to have load factors as high as 70 per cent.

The additional maximum demand to be expected from the railway load was therefore small compared both with the present demand and with the expected general growth. On the other hand, while the diversity between the present largely suburban traction load and the general system load was small, main-line electrification offered the prospect of higher figures and a welcome improvement in the system load factor.

As spread over 10 years the annual increase in the railway load would only be 32 MW compared with the present annual increase in the general load of 1,000 MW, it was clear that there would be no embarrassment to the public system if the Railway Plan were to be considerably expanded. The question therefore was to what extent the half-way house policy of partial electrification and partial "Dieselisation," followed by further electrification, should be applied, having regard to the rapid developments which had taken place since the Plan was formulated. The economics of the high-voltage alternating-current system had been recognised and it might well be that practical experience would lead to more comprehensive electrification than had so far been contemplated.

ELECTRIC LOCOMOTIVE DESIGN

At the meeting on Friday afternoon the papers considered were "Electricity in Locomotives" by Mr. C. M. Cock; "Electric Multiple Unit Trains and Equipment," by Mr. F. A. Manley; and "Electric Signalling Systems for Rail and Road Transport," by Mr. D. G. Shipp.

In his paper Mr. Cock gave a detailed review of the mechanical design and electrical equip-

ment of main line electric and thermo-electric locomotives, the use of which was extending on the railways of the world. In his opinion there was little prospect of major improvements in the reciprocating steam locomotive. It was true it was steady, reliable and cheaper, but modern alternatives were even more reliable and could be much more economical in suitable conditions. The electric locomotive was the most powerful and efficient of all types; and was also the easiest to maintain.

Where electrification could not be justified the Diesel locomotive was rapidly supplanting steam, and more recently the gas turbine had entered the traction field. Reference was made to the economics of both these types of locomotive. In all three forms of motive power—electric, Diesel and gas turbine—there was ample scope for further development and improvement and, depending on the merits of the case, each in future would find increasing application on the world's railways.

MULTIPLE-UNIT OPERATION

In his paper on "Electric Multiple Unit Trains and Equipment" Mr. F. A. Manley gave a review of current practice in which he pointed out that this type of rolling stock provided the advantages of high acceleration, maximum passenger capacity and ready adjustment to varying traffic demands. A combination of high acceleration and high maximum running speed would be obtained with the new trains on the Liverpool Street-Southend line where a maximum of 68 m.p.h. and an average of 41·5 m.p.h., including 30 seconds at each station stop, would be reached.

It was the general British practice for the motors to be mounted on the bogies with half their weight resting directly on the driven axles and driving through spur gearing. In the United States and Canada, on the other hand, some use was being made of relatively low power high speed motors which drove the road wheel axle through cardan shafts and right angle gearing. While at present the standard practice was to design the motor windings for a peak operating temperature of 145 deg. C., the mean service temperature being about 110 deg. C., developments in insulation techniques might result in higher temperatures being used in future.

Successful endeavours were being made to reduce the size and weight of the motors. For instance, the weight of the motors for the new Euston-Watford stock of the London Midland Region would be only 4,840 lb. including gear and gear case, compared with the 7,840 lb. on the 1926 stock. Operation would, however, be on the same service and to the same schedule. Development was also taking place in the design of the shoe type of collector so as to give a longer life without increased wear on the conductor rail and to permit train operation at higher speeds.

Dealing with control systems, Mr. Manley pointed out that when alternating-current motor cars were equipped with direct-current motors supplied through rectifiers, control could be by voltage variation through transformer tappings, or by direct-current control equipment working off a constant rectifier voltage, or by a combination of the two methods. This type of equipment was, however, in the experimental stage and no general practice had as yet emerged.

ELECTRIC SIGNALLING

Dealing with electric signalling at the same meeting Mr. D. C. Shipp pointed out that the greater part of British railways were still signalled on the manual block system, with telegraph communication between signal boxes. Electric interlocking had, however, been introduced between the block telegraph instruments and the signalling apparatus as a safeguard against forgetfulness and misunderstanding. The modern method was to use a continuously track-circuited block which permitted the train to protect itself, eliminated the delay of block telegraph communications and provided security independently of the signalman's vigilance. Electrically-operated points and signals also reduced manual effort as well as the number of signal boxes.

Ultimate safety, however, depended on the observance of signals by the driver, and the author therefore suggested that a system of automatic train control might in certain circumstances be provided as a final safeguard against non-observance of signals. While improved safety and economy in working justified the introduction of track-circuit block working and colour-light signals, centralised traffic control systems, which were not at present used in this country, would permit an even wider adoption of this principle.

ELECTRIFICATION IN THE COMMONWEALTH

The first paper to be considered at the meeting in the Pavilion on Saturday morning was on "Railway Electrification in the Commonwealth," in which Messrs. E. L. E. Wheatcroft and H. H. C. Barton recorded that up to 1939, some 1,160 route miles of railway had been electrified in Australia, India, South Africa and New Zealand; while since the war some 580 miles had been converted or were being converted.

With the exception of the St. Cleir Tunnel and the Toronto Subway all electric railways in the Commonwealth were equipped on the direct-current overhead system for voltages between 1,500 volts and 3,000 volts. It was unlikely that the low-frequency alternating-current system would be adopted for any future electrification, but the relative advantages of the direct-current system and the standard-frequency system would have to be considered and technical particulars relating to them were outlined and compared in the paper.

An examination of the costs of electrification and "Dieselisation" showed that high traffic density favoured the former. "Dieselisation" could, however, be adopted as a preliminary stage on many main-line electrifications since the locomotives could generally be subsequently transferred to other sections. Since electrification there had been an increase in the traffic of 340 per cent. in 14 years at Bombay; of 50 per cent. in three years at Cape Town and Witwatersrand; and of 200 per cent. in 10 years at Wellington (New Zealand).

FUTURE PROSPECTS

Discussing the prospects of further railway electrification in the Commonwealth, progress in Australia said the authors, would depend on the relationship between the costs of coal, electric power and imported oil, until locally produced oil became available in quantity. In Canada, on the other hand, oil was a major resource and it was unlikely that main-line electrification could be justified in preference to Diesel traction. In East Africa an investigation had been made into the economics of electric and Diesel working over the heavily-graded main line between Mombasa and Nakuru. This revealed that at the present cost of oil and electricity Diesel operation would be the cheaper.

In India, which was a coal and not as yet an oil producing country, electrification was likely to replace steam traction on the main lines. The extension of some existing electrically operated routes was planned and also the conversion of the main line between Calcutta and Moghal Sarai. The prospects for railway electrification in New Zealand seemed good in the long run, but in Nigeria investigation showed that "Dieselisation" would be more economic than electrification in the Lagos-Ibadan and Port Harcourt-Enugu sections. The increased traffic on the latter section had rendered re-examination of the question necessary and this was being undertaken by the authors.

The completion of the Kariba hydro-electric project in Northern Rhodesia would undoubtedly have a bearing on railway electrification in that country. It was already proposed to operate the Sinoia-Kafue direct route electrically on account of the severe gradients across the Zambesi valley. Other sections of line, now steam operated, were also being considered for electrification. South Africa, like India, was a coal and not an oil-producing country, and it was likely that substantial extensions would be made to the already extensive electrified system.

PASSENGER ROAD VEHICLES

At a meeting which was held in the Town Hall on Monday afternoon, papers were presented on "Passenger Electric Road Vehicles" by Mr. S. H. Cansdale, and on "Battery Electric Vehicles" by Mr. V. W. Dale, on behalf of the Electric Vehicle Association of Great Britain.

Mr. Cansdale pointed out that the problem of traffic congestion on roads was becoming increasingly acute all over the world, while associated with it was the air pollution which occurred owing to the rise in the number of internal combustion engined vehicles and the reduction in the speed of traffic on city streets. This being so, the claims of electrically driven vehicles must be re-examined, the present general policy in this country of using Diesel buses for all purposes being contrary to tendencies both on the Continent and in the United States.

Although out of favour in Great Britain the tramcar was still extensively used elsewhere. In its modern form it was fast, quiet, comfortable and economical and could carry heavy traffic with much less road congestion than buses. It could also be used on inter-urban routes where private rights of way permitted it to run as a light railway.

For traffic which was not heavy enough to justify the expense of rails as well as overhead equipment, the trolley bus had many advantages over the motor bus. Its smooth, but rapid, acceleration and its quiet and fumeless operation made it an ideal vehicle for city traffic of minimum density. In its various forms it was a favourite with the travelling public.

A new form of electric vehicle, the gyrobus, had recently been tried out on a small scale. It offered interesting possibilities for special applications, but was unlikely to have as wide a field as trolley buses and trams.

The need to reconsider the claims of electric traction for road vehicles was in Mr. Cansdale's opinion obvious, owing to rising costs and a probable shortage of oil. Against this could be put the comparatively stable cost of electric power and the promise of an ample supply in the future from nuclear power stations.

BATTERY VEHICLES

In the paper presented by Mr. V. W. Dale on electric vehicles, but of which Messrs. H. W. Heyman, P. Rochs and H. R. Simpson were the authors, attention was drawn to the effect of delivery costs on the cost of living. Electric battery vehicles were valuable for short hauls, and frequent-stop delivery service, as was shown by the fact that between 1947 and 1954 the number in use had been doubled and that they were employed by more than 30 different trades.

Owing to their rapid acceleration between stops they could operate at a higher average speed over a delivery route than any other type of vehicle. Increased speed of delivery was also assisted by such features as low deck height which facilitated loading, unloading, entry and exit, and there were no delays in starting. They could be successfully employed in hilly districts, were silent, clean and efficient in operation and were not difficult to start in winter. Those at present in use represented a saving of 19 million gallons of petrol per annum and their development would tend further to reduce imports.

As regards electricity consumption some 165 million kilowatt-hours were used in 1954, practically all of which was taken for battery charging during off-peak hours, so that full development would create a considerable increase in the off-peak load and improve the diversity factor.

The electric battery truck was also finding extensive application for internal transport in factories as well as for shunting in goods yards and at power stations, and for haulage in mines and quarries. In future, battery driven electric rail cars might be used for shuttle services on branch lines.

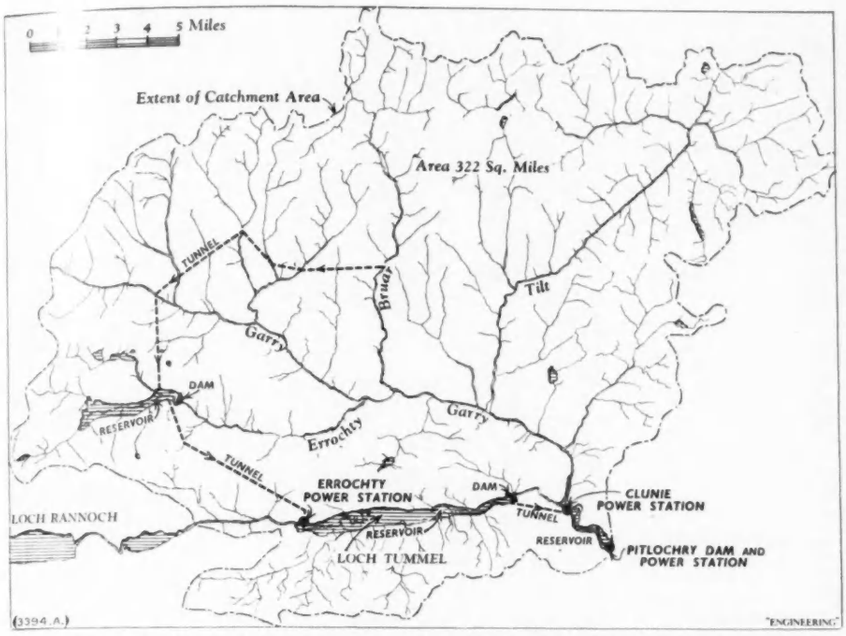

Fig. 1 Map of the Tummel-Garry scheme of the North of Scotland Hydro-Electric Board, showing the position of the Errochty power station.

AUTOMATICALLY CONTROLLED HYDRO-ELECTRIC PLANT

MODERN EQUIPMENT AT ERROCHTY POWER STATION

The Errochty power station, the first set in which has recently been commissioned, forms part of the Tummel-Garry scheme of the North of Scotland Hydro-Electric Board and is of interest in that it will be automatically operated from a Group Control Centre near Loch Faskally.

The main features of the scheme, as originally planned, have already been dealt with in ENGINEERING,* *but it may be recalled that it was designed to utilise the resources of a catchment area of 706 sq. miles, mostly in the Grampian Mountains where the annual rainfall varies from 120 in. in the uplands to 35 in. in the valleys. The run-off was to be collected in a number of water courses, all of which are tributaries of the River Tay. The head waters of the River Spey were also to be utilised.*

The scheme was also designed to generate electricity in six power stations, of which those at Rannoch (48 MW) and Tummel Bridge (34 MW) were built before the war and those at Clunie (61·2 MW), Pitlochry (15 MW) and Gaur (6·4 MW) since 1945. The Errochty power station, which is described in detail below, is now in course of construction and will have an eventual capacity of 75 MW. The combined annual output of these stations will, it is estimated, be about 600 million kWh.

Consent has also recently been given to the erection of two further stations, which will add about 32·7 million kWh to the above total. One of these will be erected at the outlet of the existing tunnel from Loch Garry to Loch Ericht and the other on the Allt Cuaich, a tributary of the River Truim, near Dalwhinnie. A number of streams will also be diverted into Loch Ericht and Loch Errochty, thus enabling a further 10 million kWh to be generated annually and the existing aqueduct from Dunalastair reservoir to Tummel Bridge power station will be enlarged, thus increasing the capacity, and outputs of the Tummel Bridge, Clunie and Pitlochry stations.

The consulting engineers for the civil engineering work connected with this scheme are Sir Alexander Gibb and Partners, while Messrs. Merz and McLellan are acting in the same capcaity for the mechanical and electrical equipment.

DAM DESIGN AND CONSTRUCTION

The catchment area of the Errochty portion of the scheme is shown in Fig. 1. It covers 86 square miles in which the average annual rainfall is 55 in. Water is collected from the River Errochty in a reservoir formed by building a dam across the glen of the same name as well as through a tunnel 12 miles long from the upper reaches of the Rivers Bruar and Garry and some of their tributaries. It then flows through a 6 mile tunnel to the power station at the western end of Loch Tummel, whence it is discharged into the loch and mingles with the flow from Tummel Bridge station to increase the output of Clunie.

The dam, which is shown under construction in Fig. 2 and for which the main contractors were A. M. Carmichael, Limited, consists of a number of buttresses, which are statically independent of each other. The upstream face of each buttress is of diamond shape, the object being to concentrate the hydraulic thrust into a comparatively small thickness of the web and at the same time to avoid tensile forces in the head. The sloping upstream face also enables the line of resultant thrust to be kept within the permissible limits of the base of the buttress with the maximum economy of material. The dam is 130 ft. high and the buttress portion 1,120 ft. long, while there is a further 180 ft. of solid gravity sections at each end. The amount of concrete required will, it is estimated, be about 175,000 cub. yards, which is 35,000 cub. yards less than would have been needed for a normal gravity dam. It will, moreover, be cheaper in spite of the higher cost of skilled labour required for the shuttering.

A draw-off culvert 6 ft. in diameter with a needle valve and disperser is incorporated in the structure and there is a free overall spillway, which is formed by widening out the tails of adjacent buttresses. There is a spillway channel and sill at the toe of the dam, which acts as a stilling pool. There is also an outlet for the compensation water.

The dam is founded on mica schist the excavation of which was complicated by the presence in the left bank of the glen of thin seams of hard silt, which were much cracked and fissured. This material was therefore jetted out where necessary and the seams filled with cement grout. The test pits that had been sunk in five places to check the disposition of the clay were also filled with concrete. The cut-off trench is close to the upstream face where holes were drilled to depths up to 120 ft. and filled with grouting by the Cementation Company, Limited, at pressures up to 190 lb. per square inch. During construction the river was diverted over the footings of one of the non-spillway buttresses and, at a later stage, through the central draw-off culvert of the dam to allow the last buttress to be completed.

A turbine driven induction generator with an output of 730 h.p. at 434 r.p.m. is installed ¾ mile downstream from the dam to make use of the compensation water. From it supplies are given to the dam through a pole-mounted transformer for lighting, heating and certain controls and to the intake for operating the gates and trash rack. Both transformers are

Fig. 2 Diamond-headed buttress dam in course of erection in Glen Errochty to form the reservoir supplying the station.

* See ENGINEERING, vol. 170, page 425 *et seq.* (1950).

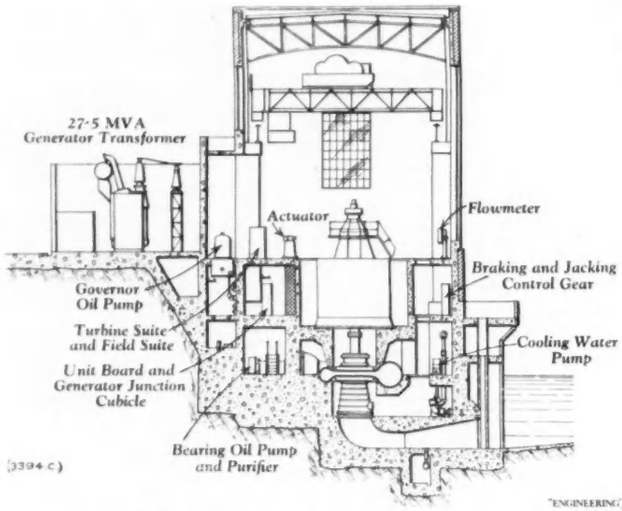

Fig. 3 Cross-section of the Errochty power station.

also connected to the Tummel-Spey Valley 33 kV line.

The concrete aggregate consists of schist drawn from the Garry-Errochty tunnel, while the sand comes from a pit at Newtonmore and the cement by road. The graded aggregates are brought to the dam site by a dumper and stored in 1,000 ton silos. They are taken thence by a belt conveyor to two 2 cub. yard concrete mixers, which discharge into 3 cub. yard skips. These skips are carried by two 7½ ton cableways across the site or by lorries and derricks to the left bank.

The concrete in the webs of the buttresses is being placed about two lifts in advance of that of the heads to facilitate the manipulation of the shuttering. This shuttering is a steel panel with soldiers and bolts to give the usual climbing arrangement and is raised by light-alloy shear-legs on each buttress.

The principal aqueduct, which brings water from the River Bruar to the reservoir, intercepting a number of streams on the way, is 12 miles long and consists of partly lined tunnels. The inlet to it is over a weir comprising a small gravity dam, which is built in a V-shape, so as to increase its capacity for dealing with flood water.

INTAKE ARRANGEMENTS

The intake to the main tunnel from the reservoir to the power station is through a trash screen and guard and control gates, which are housed in a reinforced concrete tower and were manufactured by Glenfield and Kennedy, Limited. The tunnel itself is of horse-shoe section with an equivalent diameter of 15 ft. 6 in. and is lined with concrete. At a distance of 29,000 ft. from the intake is a surge shaft 600 ft. deep, to construct which two pilot stopes were driven. To avoid the difficulties of driving a vertical shaft these stopes were inclined at 60 deg. and spiralled in four successive legs just inside the line of the circumference of the finished shaft. Enlargement to full size was then effected from the lower tunnel and the vertical shaft was concreted with climbing shutters.

The circular pressure tunnel, which extends from the base of the surge shaft to the trifurcation before the power station is 15 ft. in diameter and has a 15 in. concrete lining, which was first grouted at low pressure to fill the voids in the crown and then in stages radially at pressures up to 375 lb. per square inch. The trifurcation at the lower end of this tunnel is of reinforced concrete with steel nosing pieces from which a steel-lined section constructed by P. and W. McLellan, leads to three pipes of 7 ft. 8 in. in diameter, which vary in thickness from ½ in. to 1⅛ in. These pipes are entirely buried right up to the turbine inlet valves.

TURBINE DESIGN

The Errochty power station, which is built near the western end of Loch Tummel, will eventually contain three sets each consisting of a 35,000 h.p. Francis turbine and a vertical shaft alternator generating three-phase current at 11 kV when running at 428 r.p.m., the safe overspeed being 810 r.p.m. A cross-section of this plant is shown in Fig. 3, while a view in the main hall is given in Fig. 4.

The turbines, which operate under a net head ranging from 492 to 575 ft., were designed by Boving and Company, Limited, and were manufactured by John Brown and Company (Clydebank), Limited. They are in the main of standard design. The runner is a one-piece steel casting with a nominal diameter of 6 ft. and is solidly coupled to the shaft, which is guided at its lower end by a sleeve bearing. The water flow through the runner is controlled by moving guide vanes, which are connected by levers and links to a regulating ring. The movements of this ring are dictated by the main servo motor, which is controlled by the turbine governor.

Water is admitted to each set through a rotary valve, 5 ft. 6 in. in diameter, with which a by-pass sluice valve is associated. Both valves are hydraulically operated and are controlled by a combined by-pass operating valve and pilot valve. Limit switches for interlocking and indicating purposes are fitted at each end of the main valve travel. An automatic relief valve, which opens when the main servo motor closes and then closes at a controlled rate so as to prevent an excessive rise of pressure in the pipe line, is also fitted. These valves were manufactured by Glenfield and Kennedy, Limited, Kilmarnock, Ayrshire.

GOVERNING SYSTEM

The turbine governing system consists of an actuator in the head of which a pendulum governor is mounted. This pendulum is driven by a synchronous motor which is supplied from a permanent magnet generator coupled to the exciter shaft of the alternator. Changes in turbine speed cause corresponding movements in the pendulum, which are transmitted by an auxiliary servomotor in the base of the actuator base to a valve which controls the admission of oil to the main servo motor piston and thus produces the required movement of the guide vane regulating ring.

Speeder gear for controlling the speed of the turbine when synchronising, which can be adjusted manually or electrically, is mounted on the actuator. A load limiter is also provided, and this varies the amount by which the main servo motor, and therefore the guide vanes of the turbine, can open.

Governor oil is supplied by an electrically-driven pump, which delivers into a receiver. The upper part of this receiver is filled with compressed air, the volume of which is automatically maintained constant by an oil-operated compressor, so that rapid governor movement is ensured. An auxiliary oil pump driven by a Pelton wheel is automatically started if the pressure should fall. There is also a standby compressor, driven by a Pelton wheel, which is used for changing the receiver when no external supply is available.

ALTERNATORS

The stator frames of the alternators, which were manufactured by the General Electric Company, Limited, one being shown in Witton works in Fig. 5, are octagonal in shape and were fabricated in two halves, which are bolted and dowelled together. The segmental core stampings are secured by dovetailed keys, which are bolted to longitudinal ribs inside the frame. The windings are of the two layer diamond type, the connections being brought out through an insulating plate near the bottom of the frame. Mica and micanite are used as insulation, while the end windings are protected by aluminium guards, which assist in guiding the cooling air through the machine.

The rotor shaft and couplings were forged in one piece, while the bodies, comprising two forged steel rims, were shrunk and keyed to a cast-steel spider which in turn was keyed to the shaft. The laminated poles are dovetailed into the body and secured by taper keys. The rotor is supported in the top bracket of the machine by a combined thrust and guide bearing of the Michell type, which is designed to carry a total load of 180 tons. This bearing is insulated from the supporting structure in order to eliminate

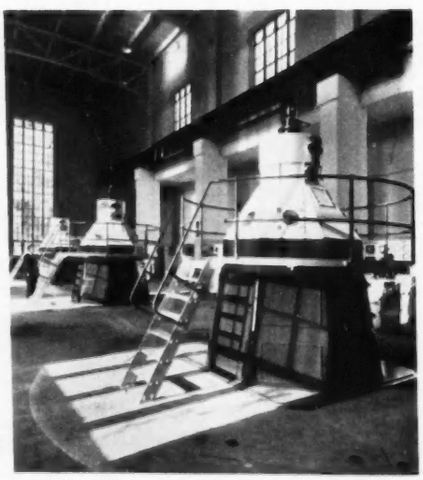

Fig. 4 Main hall of the power station showing the exciters of the three 25 MW alternators.

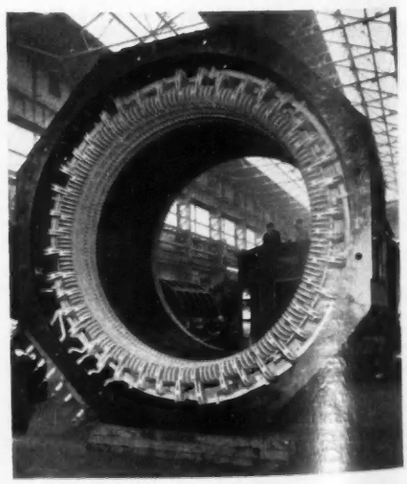

Fig. 5 The stator of one of the Errochty alternators.

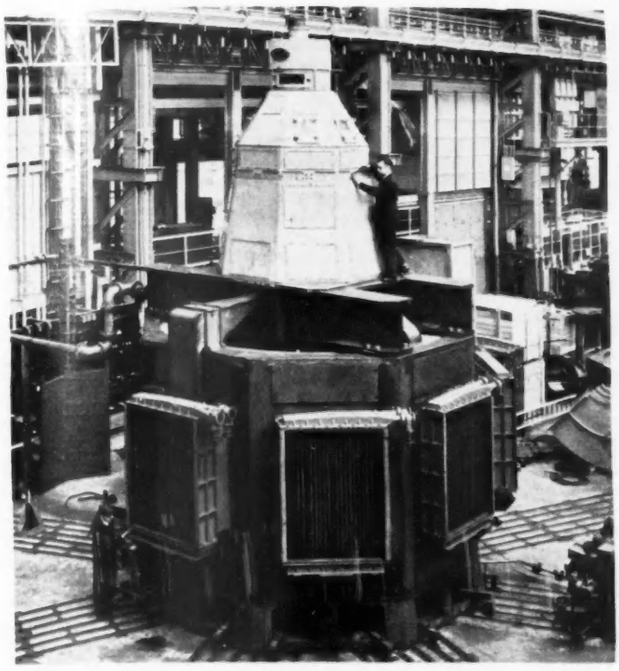

Fig. 6 One of the 25 MW alternators on the test bed at Witton, showing the arrangement of the coolers.

circulating currents in the rotor shaft. As previously mentioned, the bottom buide bearing is of the sleeve type.

MAIN AND PILOT EXCITERS

The armatures of the main and pilot exciters are mounted on a shaft which also carries the cupro-nickel alternator slip rings and is solidly coupled to the alternator shaft. The main exciter is separately excited, while the compound-current pilot exciter is provided with a shunt field regulator for the initial adjustment of the field current. The permanent-magnet alternator for supplying power to the turbine governor motors is flexibly coupled to the exciter shaft, the speed-limiting device and tachometer being mounted above it. Since the exciters are enclosed, bulkhead lighting fittings are provided to illuminate the interior of the housings containing the commutators, slip rings and brush gear, so that they can be observed through inspection windows. Access to the brush gear for maintenance purposes is obtainable from a raised platform through hinged doors.

COOLING SYSTEM

The alternator cooling system consists of a closed circuit through which air from the machine pit is forced by two centrifugal fans, one at each end of the rotor, and is returned to the pit through a cooler. This cooler, which was manufactured by the Premier Cooler and Engineering Company, Limited, comprises eight self-contained sections which are mounted round the shell of the machine. Six of these sections have a capacity of 7,260 cub. ft. of air per minute and the other two a capacity of 8,220 cub. ft. per minute. Any seven units are capable of dissipating the full-load losses. The six smaller sections are fitted with dampers to permit air to be by-passed into the station for warming purposes. The coolers are supplied with water from the tail race by two vertical centrifugal pumps, which are driven by 20 h.p. squirrel-cage motors. With a water inlet temperature of 18 deg. C. and a rate of flow of 616 gallons per minute per temperature of 60,000 cub. ft. of air per m e can be reduced from 50 deg. to 27 deg. The arrangement of these coolers can be en in Fig. 6, which shows one of the alterna on the test bed at the Witton works.

The rnator guide and thrust bearings are lubrica t a pressure of 100 lb. per square inch by a M es pump with a capacity of 78 gallons per mi which is driven by an 11 h.p. motor. There so a stand-by pump, the motor of which is supplied from an independent source. This comes into action automatically if the rate of oil flow falls below a pre-set value. The oil circuit includes an Auto-Kleen strainer and a Serck oil cooler, which is capable of dissipating 18,000 B.Th.U. per minute.

BRAKING AND JACKING EQUIPMENT

The braking and jacking equipment with which each set is to be provided was constructed by Jones, Tate and Company, Limited. It is illustrated in Fig. 7, and comprises six equally spaced rams acting upon a brake ring secured to the base of the rotor. The top of each ram forms a flat plate which carries a heavy brake lining. The rams are forced upward by oil at a pressure of 100 lb. per square inch, thus providing a retarding torque capable of stopping the rotor in about 2½ min. The brakes cannot be applied until the rotor speed is less than normal.

The jacking system enables the rotor to be lifted when it is at rest, allows an unrestricted flow of oil to be forced through the thrust bearing pads when the machine is started up after a prolonged shut down and also permits maintenance work to be carried out. For these purposes oil is supplied to the rams at a pressure of 1,500 lb. per square inch by a high speed pump manufactured by Towler Brothers. Limit switches on the cylinders restrict the upward travel of the rams so that each rises to exactly the same height. If these switches fail, mechanical stops come into operation and the excess oil supplied by the pump is returned to the tank through a high pressure relief valve which is operated by a solenoid.

Electrical interlocks ensure that the machine can only be started when all the rams are in the fully lowered position. Manually operated sustaining screws are provided to support the rotor in the elevated position. Mechanical locking gear is provided to prevent these screws from being raised or lowered until the rams have been elevated. This arrangement also prevents the screws from being engaged when the rams are being used for braking, as it is necessary to lift the rotor slightly, even when the brake linings are worn, before the locks are cleared.

REMOTE AND LOCAL CONTROL ARRANGEMENTS

As already stated operation of the station may be effected automatically either by remote control from Faskally or by local control in the station itself. There are also facilities for local manual control. The main items of the control gear for each set, most of which was supplied by the General Electric Company, Limited, are housed in a turbine and a field "suite" on the main floor of the turbine room; and on a unit board which is installed, together with a generator junction cubicle in which the main control connections are marshalled, in the alternator chamber on the floor below. Fig. 8 shows the unit board and generator junction cubicle for one of the three alternators.

Local automatic control is effected from the turbine suite, where all the controllers, meters, gauges and thermometers, as well as a system of indicators and alarms, are mounted on the turbine panel; and the majority of the associated relays and contactors, including the "interposing" relays through which remote control is effected are mounted on another panel. The field suite houses the automatic voltage regulator and its associated equipment. The starters for the motors driving the governor and bearing oil pumps and the cooling water pump are mounted on a unit board, a three-phase supply at 415 volts for operating this portion of the equipment being drawn from the corresponding unit transformer. The motor driving the stand-by bearing oil pump and other auxiliary drives are also controlled from this board, although their starters are connected to the common service board, so that they can be operated when the main sets are not running.

OPERATING PROCEDURE

As regards the operation of this control system closing the field switch places the set under the overall control of a master relay on the turbine contactor panel. When the selector switches mentioned above are set to "manual" this relay is energised by a limit switch as soon as the guide vanes have been unlocked. Under "local automatic" control

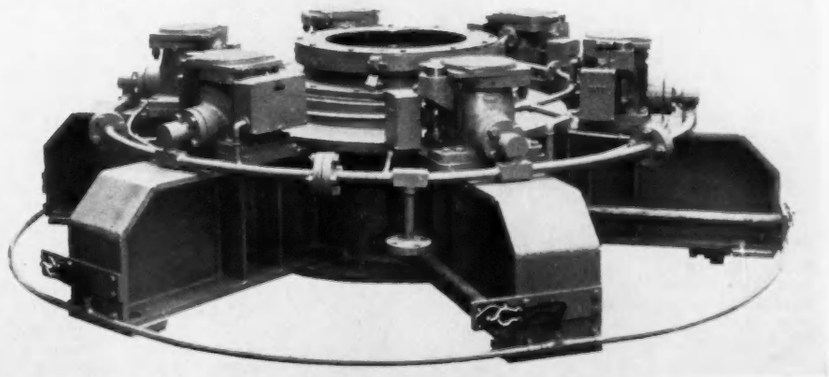

Fig. 7 Rotor braking and jacking equipment, showing the six rams

the relay is closed by the " start " push buttons and under " remote " control by contacts on an interposing relay. Contacts on the master relay then energise the " start " and " stop " bus wires and thereby automatically operate the set. An emergency shut-down is intiated either by a relay, which operates under certain alarm conditions, or by a timer, which comes into action if the time taken to bring the generator up to speed with all the auxiliaries operating correctly should exceed a pre-determined value.

Dealing with these arrangements in more detail the opening or closing of the main turbine inlet valve is effected manually by a controller or automatically by energising the " start " or " stop " bus wires. In both cases a limit switch prevents the valve from being opened unless the guide vanes are locked or from being closed unless the guide vanes are closed. The valve may also be prevented from closing by a lock-out relay or, in emergency, may be closed by the turbine shut-down relay.

As soon as the inlet valve begins to open a line-delay relay is energised and isolates the valve solenoids from automatic control, if the time required for complete travel is excessive. Any further movement of the valve is therefore the result of deliberate manual action. The relay is de-energised when, after functioning normally, the valve reaches the fully open position.

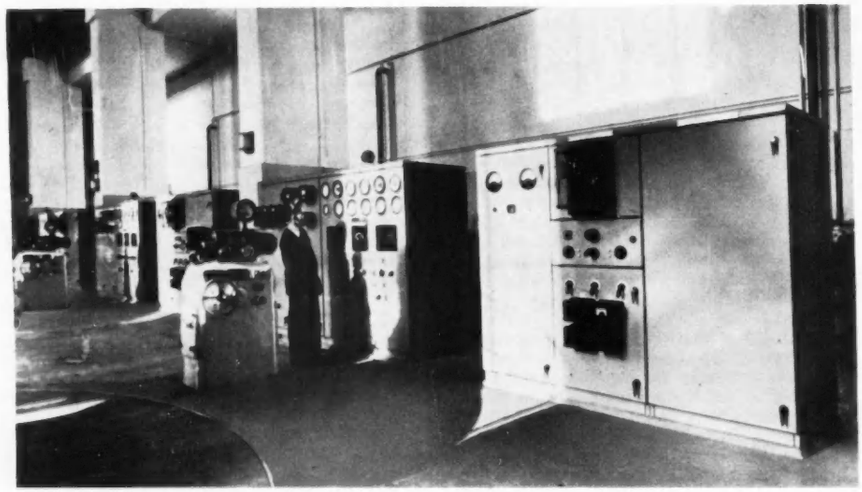

Fig. 8 Unit board and generator junction cubicle for one of the alternators.

GUIDE VANE LIMIT SWITCHES

The guide vanes are operated under manual control by push buttons on the actuator, a system of limit switches and interlocks ensuring that before they can be opened the rotor jacks are fully lowered and the sustaining screws are withdrawn; the load limiter is in the fully closed position; and the inlet oil to the main servo motor is at normal pressure. Under automatic control it is also ensured that the bearings are being adequately lubricated; that the main inlet valve is open before the guide vanes are opened; and that the actuator is closed before the vanes. In this case, too, the shut-down relay exercises an over-riding control. A meter on the turbine panel, which is energised by an auxiliary relay, records the time that the guide vanes are open.

The motor for the speeder gear on the actuator can be operated under either manual or local automatic control or under remote automatic control by an interposing relay. In all these cases the circuit is broken by limit switches at the maximum and minimum settings. The load limiter is only driven by a motor when automatic control is being used. To raise the load the motor is energised from the " start " bus wire, provided the guide vanes are unlocked. The limiter is then driven until the fully open position is reached when the circuit is broken by a switch. A supply for lowering the load is taken from the " stop " bus wire and a second switch opens when the limiter is fully closed.

The motors driving the governor and bearing oil and the circulating water pumps are controlled by contactor starters of the latching type, which are operated by " start " and " stop " buttons. The motor of the stand-by pump for the bearing oil (which is supplied from the common services board and is used during starting as the main motors are fed from the unit transformer) is normally operated through the " start " bus wire, although it can be manually controlled for test purposes. Under all conditions, however, its contactor is controlled by a relay, which starts the pump as soon as the flow falls below 4,500 gallons per hour. The stand-by cooling water pump can also be controlled by push buttons, or automatically by a no-voltage relay on any one of the sets, selection being made by a switch on the starter.

The 5 h.p. motor driving the pump for de-watering the draft tubes, so that access may be obtained to the underside of the turbine runner, is controlled by a starter with emergency trip buttons, while the 2 h.p. motor driving the drainage pump for removing water from a sump in the lowest part of the station can also be operated by a relay, which is controlled by two electrodes one at the high water and the other at the low water level.

VOLTAGE CONTROL ARRANGEMENTS

The voltage of the generator is controlled by an automatic regulator of the vibrating contact type, which was manufactured by Metropolitan-Vickers Electrical Company, Limited. The moving contacts are vibrated between two adjustable fixed contacts by a motor-driven cam, the relative position of the two sets being controlled by a coil. Coarse and fine regulation are provided and more precise control of the excitation is also available when the voltage deviation is about 5 per cent. The alternator can be run up or shut down automatically under the control of the regulator and compensation for parallel running is provided by the quadrature droop method. The components of the compensating current proportional to the wattful and wattless components of the line drop are summated by a mixing transformer, which will eventually be common to all three sets.

The operating coil of the regulator is provided with a frequency compensated positive phase sequence supply. No-volt protection is afforded by a relay which discriminates between a low voltage due to a system fault and a low voltage due to a failure of the control circuit. Forcing of the excitation, if the reference voltage should fail, is therefore prevented. Power for operating the regulator is normally obtained from the station battery, but the connections are automatically transferred to the pilot exciter when the set is running and synchronised. The generator voltage may also be adjusted by controlling the motor driving the exciter field rheostat either locally or remotely from the Group Control Centre. The field switch is manually operated, but is automatically tripped by the shut-down relay of the turbine.

A comprehensive system of indicating lamps and flag relays is installed, both at the station and at the Group Control Centre. Local indication is, however, only given when the plant is under either manual or local automatic control. The alarm units then actuate a bell and beacon lamp on the turbine panel of the set concerned, repeat alarms being initiated at the Group Control Centre for certain selected conditions.

SWITCHING AND CONTROL ARRANGEMENTS

The output of the station is stepped up to 132 kV by 27·5 MVA Bruce Peebles transformers and is transmitted by Pirelli-General oil-filled cables to the adjacent Errochty switching station to which all the other Tummel-Garry stations are coupled. This station, which controls the output of all the Tummel-Garry generating plant and the lines to Abernethy, Bonnybridge, Killin, Sloy and Fort Augustus, is equipped with solenoid-operated large bulk oil circuit-breakers of British Thomson-Houston manufacture with self-compensating arc control pots. It contains two single busbars and is arranged so that each circuit occupies a separate bay. The incoming and outgoing overhead lines are being protected by a high-speed lock in carrier-current system.

The load dispatching centre from which, as already mentioned, all the Tummel-Garry stations are controlled is equipped with light current direct-wire equipment for the Errochty power and substation and with supervising equipment for the Tummel power and substation. The other stations in the group are continuously indicated and the total load on each is shown. The load transfer station at Abernethy is controlled by supervisory equipment and that at Bonnybridge is indicated in the same way.

At Abernethy, Bonnybridge, Clunie, Pitlochry and Rannoch the supervising equipment operates on a two-tone voice-frequency telegraph installation. This in turn is applied to the power line carrier equipment which is imposed on the 132 kV lines. Errochty and Tummel power stations operate through underground pilot cables. A main diagram panel equipped with single aspect three lamp indicators shows the positions of the circuit-breakers and isolators. The control desk has panels for the three machines at Errochty and the two at Tummel as well as facilities for controlling the dam and aqueduct gates at Dunalastair and the weir at Kinlochrannoch. A complete pictorial representation of the Tummel-Garry area with indications of the water level and of the total generated loads at keypoints is given on a second panel.

The consulting engineers for the civil engineering portion of the Tummell-Garry scheme are Sir Alexander Gibb and Partners, Queen Anne's Lodge, Westminster, London, S.W.1, while Messrs. Merz and McLellan, Milburn, Esher, Surrey, are responsible for the mechanical and electrical work.

The main civil engineering contractors are A. M. Carmichael, Ltd., Edinburgh, while the grouting was carried out by the Cementation Co. Ltd., Doncaster. The steel lining of the tunnel was supplied by P. and W. McLellan Limited Glasgow, S.1, and the gates and screens by Glenfield and Kennedy, Ltd., Kilmarnock.

The turbines were designed by Boving and Co. Ltd., 56 Kingsway, London, W.C.2, and were manufactured by John Brown and Co. (Clydebank), Ltd., Clydebank. The alternators were constructed by the General Electric Co. Ltd., Kingsway, London, W.C.2, the step-up transformer by Bruce Peebles and Co. Ltd., Edinburgh, and the 132 kV and auxiliary switchgear by the British Thomson-Houston Co. Ltd., Rugby, while the compensation water turbine at Errochty was constructed by Gilbert Gilkes and Gordon Ltd., Kendal, the alternator being of Bruce Peebles manufacture. The 132 kV oil filled cables were made by Pirelli-General Cable Works, Ltd., 343 Euston Road, London, N.W.1, and the control indicating and telemetering equipment by Standard Telephones and Cables Limited, Aldwych, London, W.C.2. The main turbo-alternators at Errochty are equipped with coolers by the Premier Cooler and Engineering Co. Ltd., Shalford, near Guildford, and Serck Radiators, Ltd., Warwick Road, Greet, Birmingham 11; with oil station pumps by Mirrlees (Engineers), Ltd., Hillington, Glasgow, with braking and jacking equipment by Jones, Tate and Co., Ltd., Bradford, and Towler Brothers, Ltd., Radley, Leeds; and with automatic voltage regulators by Metropolitan Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17

Book Reviews

COLONEL BY'S MONUMENT

Rideau Waterway. By ROBERT LEGGET. *University of Toronto Press* and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (40*s.*)

The official name for the channel which is the subject of this book is the Rideau Canal, but Mr. Legget, feeling that that title indicated a "murky industrial trafficway," has preferred the name Rideau Waterway for "a silver chain of rivers and lakes . . . one of the most beautiful of all the inland water routes of North America." Although it is to-day a summer playground, it had its origin in the demands of war time and holds a place in the military history of Canada. The early days of that history are concerned with the struggle between Great Britain and France which was ended by the Treaty of Paris of 1768, ceding a large section of the eastern part of North America to this country. The American War of Independence broke out in 1774, and terminated with the Peace of Paris in 1783; this determined the boundary between America and what was then Canada. This, however, proved far from marking the end of hostilities. Great Britain became engaged in the Napoleonic Wars and the famous Orders in Council, which paralysed American commerce, led to the war between Great Britain and the United States, which lasted from 1812 to 1814. A Treaty of Peace was signed on January 8, 1815, and signalised the last time that the two countries met in combat.

The Rideau Canal was constructed between 1826 and 1832, years which do not fall within the long period marked by intermittent hostilities. None-the-less, the canal was built as a war measure. It connects Ottawa on the Ottawa River with Kingston on the St. Lawrence. These rivers meet at Montreal and the canal forms the third side of a triangle embraced by them. Although a peace treaty, which proved enduring, had been signed, mutual suspicion continued. Kingston was the principal military station of the province and it was feared that communication between that town and Montreal might be severed by military action on the St. Lawrence River by the United States. That river formed, and still forms, the international boundary, but the Ottawa was a wholly Canadian river and the construction of the Rideau Canal provided a route to Kingston lying entirely in Canadian territory.

The Rideau Canal is 123¼ miles long. Some 18 miles of the total length are artificial waterways; the remainder is formed by lakes lying on the route and by regulated rivers. There are 47 locks with a total lift, up and down, of 439 ft.; all locks are 134 ft. long and 33 ft. wide. The main channel has a minimum width of 60 ft. at the bottomm and 80 ft. at the top. Boats drawing up to 5½ ft. may normally pass through the canal. It was built through virgin land with none of the machinery or equipment which would now be available, in less than six years at a cost of £800,000.

The Rideau Canal is the monument to Lieutenant-Colonel John By, of the Royal Engineers. He arrived in Quebec on May 30, 1826, with instructions to complete a water communication from the Ottawa River to Kingston. He set to work at once against great material and financial difficulties and with more opposition than assistance from official quarters. The detail history of his endeavours and achievement will be found in Mr. Legget's admirable book. The work was carried out by a number of contractors and there were many disputes about costs and estimates, and difficulties in obtaining skilled labour and material. In dedicating his book, Mr. Legget has added a tribute to "workers, contractors, engineers." This is certainly deserved, but the inspiration and drive came from Colonel By whose sole satisfaction in the matter must have been the successful completion of his great work. He received no official recognition or award. This omission was in some measure made good by the ceremony, recorded in our issue of November 25, 1955, when one of Sir Charles Barry's fountains from Trafalgar Square in London was unveiled in his honour at Ottawa. Mr. Legget has added a second worthy memorial.

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FACTS ABOUT ASBESTOS

Asbestos: Its Origin, Production and Utilization. By W. E. SINCLAIR. *Mining Publications, Limited*, 482 *Salisbury House, London Wall, London, E.C.*2. (50*s.*)

Very little literature is available in English on asbestos; the well-known book by Becker and Haag has been out of print since before the war.* It has been supplemented by Commonwealth and U.S. Government publications, but beyond this the student is driven to study the many technical papers of direct and partial reference to the subject. Mr. Sinclair's book will therefore be most helpful since it brings up-to-date, and once more makes available in the U.K., a comprehensive book on asbestos.

The book divides naturally into four parts. The first is on the nature of asbestos. The various types of asbestos are described together with the principal characteristics and identification points. Much of the tabulated data comes from work published before the last war, and since modern identification techniques are based upon X-ray crystallography it is unfortunate that greater reference is not made to it at this stage, perhaps with relevant identification tables. A most interesting passage concerns the geological origin of the types of asbestos, and this controversial subject is very bravely treated.

The next section deals thoroughly and competently with the mining and production of minerals. There are theoretical diagrams of mining methods supported by illustrations from mines in Canada, Rhodesia and South Africa. The production of fibres is described in considerable detail, with satisfactory process flowsheets; particular attention is paid to the all-important subject of air-flow separation, and the main text is supplemented in an appendix.

In the section devoted to commercial application, the main purposes for which asbestos is used are clearly described. The impression is gained, however, that the author is not in such close touch with his subject as in the other parts of the book. This is unfortunate, since to many, and particularly to those not actively engaged in producing the raw material, this is a most important section for enlightenment and instruction. Chrysotile asbestos is used for most applications in the U.K.; crocidolite and amosite satisfy specialist and limited applications. There is a tendency for the author to suggest the opposite view. The statement that chrysotile is decomposed by seawater is hard to understand as it is not substantiated by other sources.

Greater reference could have been made to the use of fabrics coated with materials such as synthetic rubber, silastomers, polyvinyl chloride, and even polytetrafluorethylene. These have come into wide use for covering thermal insulation, fire seals, connecting sleeves and other purposes where flexibility, temperature or chemical resistance are required. Similarly, a greater mention might have been made of the use of asbestos fibres in conjunction with polyester, phenolic and silicone resins as materials of construction for structures varying from radar reflectors 16 ft. in diameter to rocket flame tubes and from aerofoils to heat-resisting handles. Some reference to the interaction of sodium silicate with asbestos would be expected as it forms such an important medium in many fabricating operations on asbestos. After an interesting chapter on substitutes and reclamation—a subject of ever-increasing importance—the writer tackles the economics of the process. It is questionable, however, if he is correct in dismissing the manufacturing resources of the United Kingdom so summarily!

The quantities of asbestos employed in the manufacture of brake linings and clutch facings seem so large that it might be interesting to consider what would be the effect on the industry if new methods of power transmission or substitutes for the present woven asbestos materials came into use. No doubt such a resourceful industry would swiftly find a use for any surplus material or plant.

One of the best features of the book is that the author has compiled a good bibliography that will greatly assist anyone wishing to make a deeper study of the subject. Throughout the book factual evidence is carefully displayed in a clear tabular manner which will enable easy reference to be made to detail when the book is in day-to-day use. The book will do much to fill the present void in literature on this "mineral of unparalleled properties."

* A second edition of the book by Becker and Haag was published in Berlin in 1952. It is not known whether it has been translated.

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TESTS FOR WELDERS

Tests for Use in the Approval of Welders. Part I: Manual Metal-Arc and Oxy-Acetylene Welding of Mild Steel and Low Alloy Steel Sheets, Plates and Sections. British Standard 2645: Part I: 1955. *British Standards Institution*, 2 *Park-street, London, W.*1. (12*s.* 6*d.*)

Over the years engineers have evolved procedures and techniques covering the application of metal-arc and oxy-acetylene manual welding to their specific production needs. To ensure adequate standards of work, it became essential that welding operators should give some evidence of their ability to do their job satisfactorily, and simple welding tests for operators were developed. The specimens so produced were tested physically—various destructive means were employed—and the results assessed. This assessment of weld quality was initially a hit and miss business, but experience of application soon provided a suitable yard stick.

Nevertheless, basic forms of test specimens had to be agreed for the application of standard methods of physical testing—and what is very important—a standard assessment of quality. To a considerable degree these needs have now been met by the publication of B.S.2645—Part I, 1955. This standard describes a series of defined tests, one or more of which can be selected for assessing or testing the capabilities of a welder working with mild steel and low-alloy steel sheets, plates and rolled sections.

Part I includes two sections. The tests in Section I, where the specified material is mild steel, are for use in the preliminary assessment of a welder's skill. They are designed only to ascertain if a welder is familiar with the usual techniques of metal-arc and oxy-acetylene welding as applied to flat steel products (sheets, plates, and rolled sections). The tests in Section II are for use in the approval of welders for specific applications in the welding of mild steel and low-alloy steel. They comprise butt and fillet welds made by both the processes.

It is expected that, in future, British Standards for welded constructions will specify the relevant tests from Section II, of British Standard No. 2645, when defining the qualification of the welders for a particular task. In the absence of a relevant application standard for a particular form of construction, standard tests can now be selected. These tests should simulate as closely as possible the types of joint on which the welder will be employed, both as regards form and position of welding.

The committee responsible for preparing this standard is now engaged on the preparation of Part II, which will cover the approval of welders engaged on tubular structures and low-pressure fluid-carrying pipework.

NEW BOOKS

Some of the books noticed here are selected for extended review in ENGINEERING.

An Introduction to Reactor Physics. By D. J. LITTLER and J. F. RAFFLE. Published for the United Kingdom Atomic Energy Authority by *Pergamon Press, Limited*, 4-5 *Fitzroy-square, London, W.*1. (25*s.*)

The title of this book, which is based on a set of declassified lectures given by the authors to the Reactor School at Harwell, is used to cover that branch of basic science involved in the design and study of nuclear reactors. The approach has been so chosen as to provide an introduction to the subject, and the only mathematical knowledge required is an understanding of simple differential equations. The early chapters give an account of nuclear physics assuming no previous knowledge and covering the field sufficiently to clarify the principles of reactor construction; following this the authors show how to calculate the critical mass of a thermal reactor and enumerate the parameters which affect reactor design, concluding with a short discussion of reactor shielding, detection of particles and health hazards. It should be noted that although particular attention is paid to the gas-cooled graphite-moderated natural-uranium reactor, the book can be regarded as an introduction to thermal reactors in general. Graphs and diagrams illustrate the text and an index is provided.

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1954. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*s.* 6*d.*)

Disappointing but not unexpected is the statement in this report that in almost every case deposits of radioactive minerals in the United Kingdom are too small to be of economic interest. A few of these domestic uranium occurrences could readily provide a small tonnage of commercial-grade ore, but the aggregate resources known to be available are insufficient to warrant the erection of an expensive leaching plant to upgrade the ore to an acceptable concentration. With uranium, as was formerly the case with copper, the trend of production is away from the little lode deposits of Cornish type, in which the mineralisation is restricted to rich but very small pockets, towards lower-grade disseminated deposits which may be worked in relatively large tonnages. Apart from the report of the Atomic Energy Division (of the Geological Survey), the progress summary includes the sectional reports of the palaeontological, petrographical, chemical and spectrographic, water, and geophysical departments, district reports, museum reports and the report of the Director, and an index is provided.

A Career in the Oversea Civil Service. By KENNETH BRADLEY. Prepared by the Colonial Office and the Central Office of Information. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

The Oversea Civil Service offers a wide range of careers, and it is principally for young people who have yet to decide on their future, and also for those who must assist them in their choice, that this booklet has been written. Service is mainly in the Crown Colonies and Protectorates and the booklet gives a clear picture of life in these territories and the kind of work (including engineering) which has to be done; it also summarises the qualities that are looked for in prospective candidates. Numerous illustrations are included and a bibliography gives scope for further reading.

Bessel Functions for Engineers. By N. W. MCLACHLAN. Second edition. *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.*4. (35*s.*)

Bessel functions have long been widely used in research and design work, and therefore form an important part of the advanced student's theoretical equipment. The purpose of this book, which is a complete revision and extension of the first edition, is to provide engineers and engineering students having no prior knowledge of the subject with a course on Bessel functions and their applications. Some of the applications with which the new edition deals are buckling of columns and variable struts, eddy-current furnaces, loudspeaker horns, oscillation of fluids, radial temperature distribution in engine cylinder walls, scattering of sound, tapered loaded electrical transmission lines and vibration of membranes. The author of the book, which includes some 30 tables of functions, a bibliography and an index, is the Professor Emeritus of Electrical Engineering, University of Illinois and Walker-Ames Professor of Electrical Engineering, University of Washington (1954).

Legal Cases for Contractors, Architects, and Engineers. By I. VERNON WERBIN. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (45*s.*)

The author has the advantage of being a Licensed Professional Engineer as well as a member of the New York Bar, and this book is written from the standpoint of his 40 years' experience in legal practice, the greater part of which has been spent in dealing with problems connected with construction work. The book is a continuation of the author's previous volumes: *Legal Phases of Construction Contracts* and *Legal Guide for Contractors, Architects and Engineers*, and is intended as a means of forewarning its readers regarding the legal difficulties likely to be encountered in dealing with construction projects in the United States. Actual cases are cited in the 52 problems discussed. A table of cases and an index are also provided.

Nomography and Empirical Equations. By DALE S. DAVIS. *Reinhold Publishing Corporation*, 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (6.75 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (54*s.*)

The use of nomographs and alignment charts in industry for the rapid solution of practical engineering problems—especially in cases where results are required for a wide range of similar products operating in different conditions—is growing rapidly. Most aspects of the subject are dealt with in this book, the first part of which explains in a readily intelligible manner empirical equations for two- and three-variable data, describing recent techniques utilising trigonometric and hyperbolic functions and the modified Gompertz equations. Part two covers the theory and construction of several forms of alignment and time co-ordinate charts important in industry. The author of this book, which is illustrated and has an index, is the Professor of Chemical Engineering at the Virginia Polytechnic Institute.

Table of Hyperbolic Sines and Cosines, x = 2 to x = 10. National Bureau of Standards Applied Mathematics Series 45. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (55 cents.)

These tables are intended to supplement those in the volume "Applied Mathematics Series 36, Tables of Circular and Hyperbolic Sines and Cosines for Radian Arguments," in which hyperbolic functions are given from $x = 0$ to $x = 2$ to nine decimal places at intervals of 0·0001; additional tables give these functions from $x = 0$ to $x = 10$ at intervals of 0·1. The present document is intended to facilitate interpolation in the range from $x = 2$ to $x = 10$ by tabulating values at intervals of 0·0001 to nine significant figures. These were computed on the National Bureau of Standards Eastern Automatic Computer (S.E.A.C.) and the results transferred to punched cards; the cards were differenced and the manuscript was then prepared on a card-controlled typewriter.

Les Turbines. By PAUL CHAMBADAL. *Librairie Armand Colin*, 103 *Boulevard Saint-Michel, Paris.* (No price given.)

Dr. Chambadal, who is the engineer in charge of research and development for Electricité de France, has prepared this monograph to form an introduction to the theory and thermodynamics of turbines. Beginning by classifying the various kinds of turbine and outlining their principles of operation, he continues with a study of compressible fluids and a discussion of impulse and reaction turbines; this is followed by sections on calculations, variables and similarity considerations. The book, which covers both gas and steam turbines, is illustrated by diagrams and includes a bibliography; it is to be followed by a companion volume on compressors. The text is in French.

Quantum Mechanics. By LEONARD I. SCHIFF. Second edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6.50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (47*s.*)

The threefold purpose of this volume is to explain the physical concepts of quantum mechanics, to describe the mathematical formalism, and to present illustrative examples of both the ideas and methods. It is intended to serve as a text at graduate level, assuming familiarity with atomic structure, classical mechanics and differential equations, and some knowledge of electromagnetic theory and the special theory of relativity. It may also be used as a reference book. Among the topics discussed are the Schrödinger wave equation and its application to energy-level problems and collision theory; the Heisenberg matrix formalism and transformation theory, and the relativistic wave equations of Schrödinger and Dirac. New material in the second edition includes the relation between the cross-section and forward scattered amplitude, the Virial theorem; Green's function and integral equation for the radial wave function; and the theory of the effective range in the neutron-proton system. The book gives problems with each chapter and contains an index; its author is Professor of Physics at Stanford University, U.S.A.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Dust. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. The characteristics of the dust occurring in air and industrial gases, especially in modern factories and transport undertakings and the methods of removing it based on six decades of experience. Data regarding particle and dust sizing and grading. An analysis of atmospheric pollution and of the dust hazard in industry, including silicatosis, asbestosis, and siderosis. The characteristics of atmosphere and industrial filters of various types with notes on the use of the vacuum cleaner in industry. Fully illustrated technical booklet. Publication 2004.

Boiler Performance Calculator. INDUSTRIAL CALCULATORS, Clarkes Buildings, Haydock-street, Warrington. Nomogram-type calculator for determining the performance and efficiency of steam boilers. A set of instruments is included to measure carbon dioxide or oxygen content of flue gases, which figures are then used in the calculation. Can be used by non-technical staff. Illustrated leaflet.

Process Heaters. BARLOW-WHITNEY, LTD., 2 Dorset-square, London, N.W.1. Electrically heated appliances such as glue pots, wax pots, immersion heaters, tinning pots, ladles and muffles. All fitted with automatic thermostatic control. Sizes include glue pots up to 6 quarts; plastic dip tanks up to 21 gallons and ovens up to 8 cub. ft. Illustrated catalogue.

Thread Forms. W. H. A. ROBERTSON & CO. LTD., Small Part Division, Lynton Works, Bedford. A guide to screw thread forms of the world, listing 60 forms in current use. Forms are grouped according to type and there is an index of 146 series from 21 countries giving references to national standards. Two-colour folder for desk or wall.

Air Motor. ALFRED BULLOWS & SONS LTD., Long-street, Walsall, Staffordshire. Improved version of L20 air motor can now run continuously for three years. Torque 400 in.-lb. at air pressure of 80 lb. per square inch giving a maximum of 25 double strokes per minute for solution agitation. Consumption 1 cub. ft. of air per minute. Leaflet.

Chemical Pumps. SIGMUND PUMPS, LTD., Team Valley, Gateshead, 11. Stainless steel (18/8/3) pumps for chemical and process duties. Sizes from 1 to 25 h.p. either 2,900 or 1,450 r.p.m., with capacities up to 300 g.p.m. Size selection charts and performance details given in publication No. 1026.

Reduction Gears. S. E. OPPERMAN LTD., Boreham Wood, Hertfordshire. Worm reduction gear ratios from 5 : 1 to 100 : 1 and horse-power up to 63 at 1,500 r.p.m. single reduction; helical and bevel gears; and geared motor units. Illustrated catalogue.

Research Bulletin. BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION, 111/112 Buckingham-avenue, Slough, Buckinghamshire. First number of a bulletin, to be issued three or four times a year, describing the organisation and activities of BICERA.

Power Factor Control. THE BELMOS CO. LTD., Bellshill, Lanarkshire. A console designed to house the multi-stage relays used in schemes for the automatic correction of power factor. Illustrated leaflet.

Water Softening. FEEDWATER SPECIALISTS CO., St. Paul's-square, Liverpool, 3. The lime-soda and base exchange processes described. Leaflet No. 200 (continued from No. 199).

Molybdenised Lubricants. ROCOL LTD., Rex House, Minories, London, E.C.3. The application and performance of lubricants containing molybdenum disulphide. Publication No. 6.

SCIENTIFIC INSTRUMENTS

ANNUAL DISPLAY BY THE PHYSICAL SOCIETY

Concluded from page 381

Sir John Cockcroft, in his opening speech at the Physical Society's exhibition held at the Horticultural Halls, London, from May 14 to May 17, referred to what he called the "stone-age" of nuclear physics, when atomic particles were counted by the scintillations they made when striking a zinc-sulphide screen. He said that observers had been able to count rather more than 60 pulses a minute without becoming confused. Nowadays electro-magnetic devices were able to count millions of scintillations a minute. He also recalled the cloud chamber invented by Professor C. T. R. Wilson and wondered what Wilson, who never spent more than £5 on a piece of apparatus in his life, would think of a project put forward in America for making a liquid-hydrogen bubble chamber costing several million dollars; also the development of the transistor was insiduously transforming the growth of electronics. Sir John referred to the exhibits of craftsmanship and draughtsmanship that had been submitted for the competition and said that the quality of these was an encouraging sign that we should not lack craftsmen in the future—craftsmen who would still be needed in industry.

PICTURE TRANSMITTER

On frequent occasions in the present day pictures have to be transmitted at speed over long distances, and for this purpose Muirhead and Company, Limited, Beckenham, Kent, were displaying a portable picture transmitter which can be used for graphic material of all sorts, wherever suitable landline facilities are available. It conforms with C.C.I.T. recommendations and may be used with any receiver similarly standardised. Power can be taken from the alternating-current mains or from a six-volt accumulator. The transmitter, which is shown in Fig. 5, has a drum for the picture allowing a maximum picture size of 8 in. by 5¼ in. Two drum speeds are available, 60 and 120 r.p.m., and the scanning pitch is 135·4 lines per inch. The line signal is an amplitude-modulated 1,300 cycles carrier and the contrast ratio is 34 decibels. The dimensions are 15 in. by 11 in. by 7 in. overall and the weight 32 lb. A telephone hand-set and loudspeaker are included in the equipment to provide speech communication with the receiver operator and oral monitoring of the outgoing signal. The synchronisation of the fork-controlled driving motor is adjustable by means of a synchronising control and can be checked at any time by a stroboscope visible through a window. A high-frequency alternator driven from the motor affords a constant-voltage supply to the scanning lamp photo-multiplier cell and to the electronic unit. The photo-multiplier cell is connected in a balanced modulator circuit which ensures that only the carrier signal modulated by the picture frequencies is transmitted. During the waiting period between transmissions, the instrument may be switched to a stand-by condition under which the loudspeaker amplifier remains operative, so that audible warning can be given when transmissions are to be renewed.

MATERIALS

Several firms were exhibiting new developments in materials and among them was the Thermal Syndicate Limited, Wallsend, Northumberland, who were showing examples of quartz. One item was a range of fused-quartz helical springs, including tapered springs, which can be used for micro-balances and similar appliances as they are not affected by atmospheric conditions. The coils are perfectly circular and the fibre is of uniform diameter throughout.

An alloy of specific properties was shown on the stand of the Post Office Engineering Department Research Station, Dollis Hill, London, N.W.2, in the form of nickel-iron magnetic strip rolled from sintered powder compacts. Nickel-iron strip rolled from ingots produced by conventional melting and casting practice may possess variations in properties between different batches; such variations require design to be based on the lowest level of properties likely to be met, which often results in unnecessarily large items. By mixing powders of the various constituents exact proportions can be consistently maintained and are reproducible in different batches. The nickel-iron strip exhibited was made in this way by mixing the powders, compacting them under pressure, sintering them in a controlled atmosphere and then rolling the resulting billet to the required thickness. By adapting a standard two-high rolling mill by attaching subsidiary rolls between the main rolls, strips down to 5 microns thick can be produced. Tests have shown that there are optimum proportions for both temperature coefficient and permeability, though these are not the same. A variation of as little as one-half per cent. of iron can change the permeability by as much as 20 per cent. in alloys near the optimum proportions.

PRESSURE CORRECTING THERMOMETER

Developed specifically for use in the boiling of jam, the differential thermometer shown by the Cambridge Instrument Company, Limited, 13 Grosvenor-place, London, S.W.1, makes automatic adjustments for changes in barometric pressure. The equipment is illustrated in Fig. 6. The thermocouple of the instrument has one junction immersed in the jam and the other in steam produced by a hypsometer, thus changes in the barometric pressure cause equal changes of temperature in the jam and the steam, and there is therefore no resultant temperature difference or thermo-electric motive force occasioned by the pressure change. A Cambridge indicating millivoltmeter is used with the equipment. The measuring element is protected by a metal guard and the stem of the instrument is provided with an adjustable clamping hook to enable it to be hung on the side of the jam-boiling pan. An adjustable wooden handle is also fitted to the stem. All connecting leads are sealed in vulcanised rubber to give waterproof joints. The equipment can, of course, be used in any other application wherever it is necessary to make temperature measurements with automatic compensation for any changes that may occur in the barometric pressure.

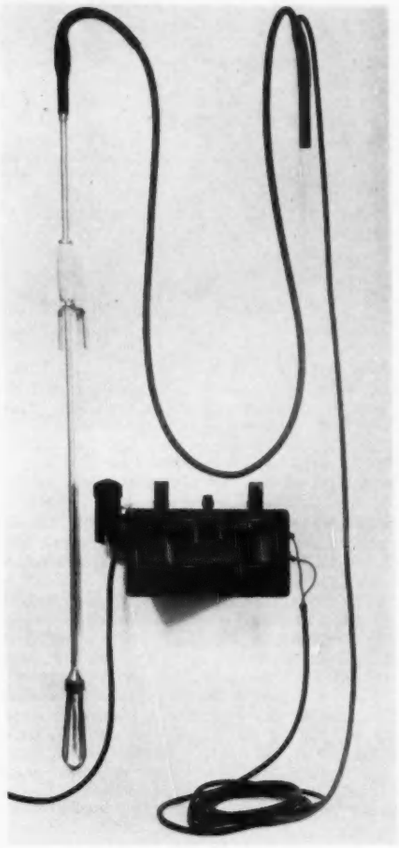

Fig. 6 Differential thermometer for pressure corrections: Cambridge Instrument Co. Ltd.

MICRO-INCINERATOR

An instrument originally devised for the purpose of the rapid drying and incineration of biological material was shown by Townson and Mercer, Limited, Croydon, Surrey. The principle is of an infra-red lamp throwing a parallel beam on to a gold-plated parabolic reflector which focusses the heat on to a small crucible. The reflector is mounted in the bottom casing of the instrument, which is shown in Fig. 7 with the lamp housing swung clear of the crucible and reflector. The crucible has a movable cover connected to a draw-off tube which can be used in connection with a filter pump to remove any noxious fumes given off during the incineration. The lamp is rated at 250 watts and can raise the temperature of the crucible to 600 deg. C. in a few minutes. The intensity of heat is pre-set so that

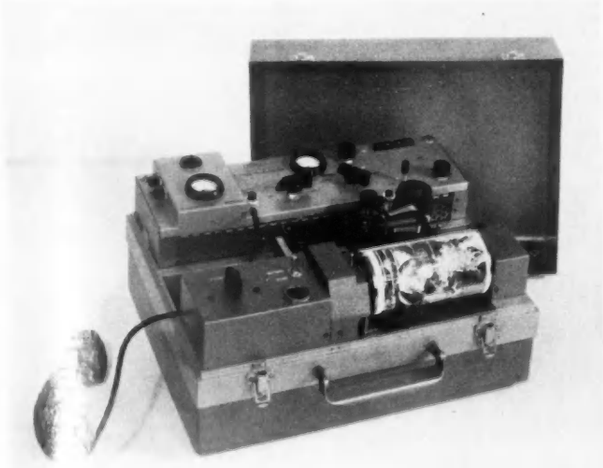

Fig. 5 Portable picture transmitter, with combined telephone handset and loudspeaker: Muirhead and Co. Ltd.

Fig. 7 Infra-red micro-incinerator (the lamp is swung clear of crucible): Townson & Mercer Ltd.

the apparatus is particularly suitable for ashing specimens for potassium and sodium estimations. The maximum temperature normally attained is about 750 deg. C.

Wet samples can be placed on the side platform and the lamp swung over them for a preliminary drying before they are placed in the crucible in the parabolic heater. This drying is quite safe even if the materials are inflammable. The base and part of the lamp housing are made of aluminium castings with a spun aluminium cone supporting the screw-type porcelain lamp holder. The parabolic reflector is of spun copper, gold plated on the inside surface. Nickel or platinum crucibles are recommended and should be approximately 1½ in. diameter by ½ in. high.

WAVE-GUIDE WATTMETER

The power output of an X-band wave-guide can be measured by a feed-through wattmeter which was being exhibited by the Wayne Kerr Laboratories, Limited, Sycamore-grove, New Malden, Surrey. It is accurate to ± 1 per cent. in the power range of 10 to 100 watts. The meter measures the mean power of a pulsed series, but under these conditions the peak power should not exceed about 50 watts. The instrument is illustrated in Fig. 8. It consists essentially of a short length of rectangular wave-guide, mounted vertically, and having suspended withing it, from a fine quartz fibre, a thin glass rod to which two thin metal vanes, one-quarter guide wave length apart, are attached. Power flowing through the wave-guide imposes a torque on the vanes and the resulting rotation is indicated by a lamp and scale, in association with a small mirror attached to the lower end of the glass rod. In use the vanes are returned to their initial 45 deg. position by means of a torsion head, and the head reading is directly proportional to the power flow. Unlike a water calorimeter the instrument does not absorb the power to be measured, the power loss being only very slightly greater than the normal loss in the same length of wave-guide; moreover, the associated equipment of the water calorimeter is not required. Secondly, the instrument is an absolute standard, and thirdly it is portable and can easily be set up in any new location.

CHECKING COILS

When many hundreds of small coils have to be wound with fine gauge wire it is a difficult task to test them for continuity and resistance, and even a very accurate resistance check may not detect a single shortened turn in a coil containing many hundreds of turns. Nash and Thompson, Limited, Oakcroft-road, Chessington, Surrey, were exhibiting a detector designed to test coils and transformer windings in the early stages of production. The instrument consists of a power unit with a meter, into which can be plugged jigs of different sizes, consisting of a small coil wound round a core which projects beyond the unit. The instrument is set up to zero with the unit in place and the coil to be tested is threaded over the projecting core and so is coupled to a tuned oscillator circuit. If there is no circuit in the coil, that is to say, no shorted turn, no current flows and the meter therefore gives no indication. If, however, there is a shorted turn a current will flow and will be shown by a deflection of the meter caused by the damping effect on the tuned oscillator. Continuity of the coil is quickly checked by shorting the ends of the coil together and thereby deliberately causing a current to flow. It is desirable that the core should approximate to the size of the coil and for this reason several plug-in units are supplied with the instrument. It is claimed that when used on the correct jig one shorted turn of 40 s.w.g. wire can be detected in the outside layer of a coil of ¾ in. radial winding depth. The instrument draws current from the ordinary alternating-current mains, consuming about 10 watts. It measures 10½ in. by 6 in. by 5¼ in. and weighs 8 pounds.

NON-CONTACT THICKNESS GAUGE

The measurement of the thickness of the lead covering of electric cables is the object of a gauging system introduced by the British Scientific Instrument Research Association, "Sira," Elmstead Woods, Chislehurst, Kent. The system used during the extrusion process. It is non-destructive and can be used at temperatures around 200 deg. C. and by any factory operative. It consists of an electro-magnetic gauging head, as shown in the illustration, Fig. 9, and is held in close proximity to the sheath so that eddy currents are induced. The strength of the eddy current is dependent on the depth of penetration into the lead and hence on the thickness. Direct contact is therefore not necessary, and the effect of variations in temperature is only small. With the device used a variation in thickness of about ¼ mil can be detected in a thickness of 100 to 150 mils, and measurements in general are within 1 per cent. The head consists of a differential transformer with a balanced output, the central coil being excited by an oscillator. The oppositely-connected output coils are connected to an amplifier and phase-sensitive detector so that the indications of the output meter can be made to correspond with variations in thickness above and below the nominal value. Alternatively, the gauge can be used to measure absolute values of thickness.

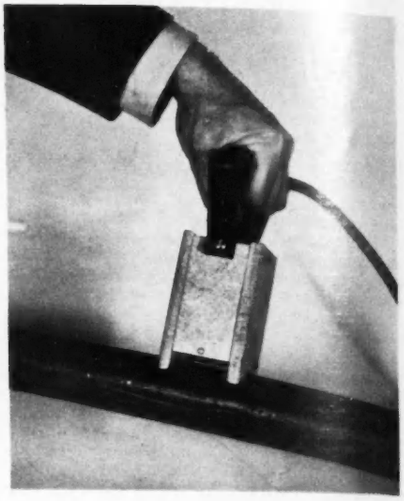

Fig. 9. Thickness measuring head: B.S.I.R.A.

FILTERING METAL

The use of liquid-metal coolants in atomic power plant has raised the question of contamination of them by impurities which tend to accumulate during service. Consequently porous stainless-steel filters have been developed by the B.S.A. Group Research Centre, Greystones Hall, Sheffield, 11, and were shown on their stand. These were developed in association with Metal and Plastic Compacts Limited, and have been used as standard equipment for some years by the United Kingdom Atomic Energy Authority. The porous stainless steel is manufactured by a modification of powder-metallurgy techniques from pre-alloyed stainless-steel powder of high purity. It combines the high strength, durability and corrosion resistance of austenitic chromium-nickel stainless-steel with a high permeability to fluids and a low limit of filtration of solid particles. All solid particles greater than 1 to 2 microns are removed. Apart from their use in atomic power plants, the filters are employed in many other branches of industry; they can be used for both liquids and for gases, particularly in connection with fluidised-bed catalyst processes in which the filters are arranged at the head of the column to prevent loss of the catalyst and any contamination of the gaseous products.

PROGRAMME CONTROLLER

An example of a programme controller made from standard parts was shown by the Morgan Crucible Company, Limited, Battersea Works, London, S.W.11. It is illustrated in Fig. 11. It was constructed to drive some control, such as the index of a temperature controller, through a pre-set programme lasting for a period of several weeks. The programme is promoted by a series of phases of uniform mean rate of rotation of a driven shaft. Ten speeds forward and reverse over a ratio of 30 : 1 are available, and the duration of each of six phases can lie between 10 minutes and 12 days. The speeds

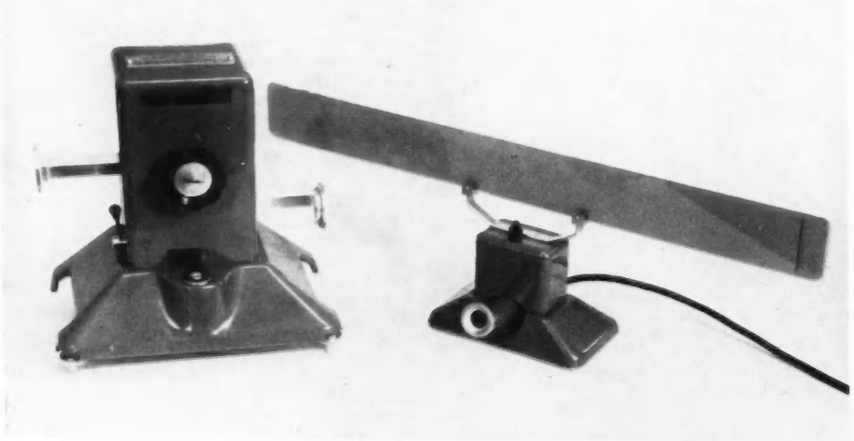

Fig. 8 Wave-guide wattmeter (light source and scale on the right): Wayne Kerr Laboratories, Ltd.

Fig. 10 Instrument for detecting lamination flaws in cold-rolled strip. British Iron and Steel Research Association.

are determined by a relay-uniselector circuit which transmits a fraction of regular 1 minute impulses to the driving motor. This turns the driving shaft through half a revolution upon the receipt of each impulse. An application used by the company is in the control of heating programmes which demand widely varying rates of rise or fall of temperature within the range of 450 deg. C. per hour maximum to 1 deg. C. per hour minimum. The duration of each phase may be pre-set between 10 minutes and 12 days and the programme can be altered during the run if required. The use of the instrument can doubtless be extended to many other applications where a long continuous programme is required.

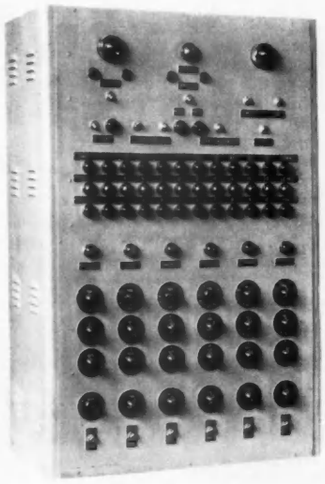

Fig. 11 Programme controller: Morgan Crucible Co. Ltd.

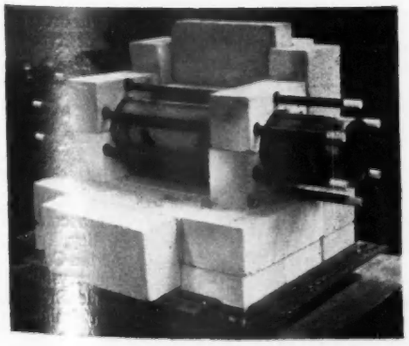

Fig. 1[illegible] Built-up oven or Furnace: Morgan Crucible Co. Ltd.

Also shown by the firm were built-up furnaces of the type shown in Fig. 12, which use a crusilite heating element mounted in insulating bricks that can be cut and drilled with any tools. The crusilite elements use silicon-carbide resistor tubes which may be run up to 1,550 deg. C. in air.

DETECTING ROLLING LAMINATIONS

A prototype instrument for detecting the presence of laminations in metal sheet was demonstrated by the British Iron and Steel Research Association, 11 Park-lane, London, W.1. It is illustrated in Fig. 10.

Laminations in metal sheet occur if defects such as piping, blow-holes or segregation were present in the ingot from which the sheet was rolled. During rolling such flaws become flattened and elongated and may eventually be of considerable size. They are a source of trouble when the sheet is moulded or pressed to shape. The instrument for detecting them consists of a pair of tongs at the end of which are two contacts, one on each face of the sheet. Current is passed between these two contacts and if the sheet is homogeneous it passes directly between them; if, however, there is a discontinuity some part of the current will be forced to flow around the discontinuity and can therefore be detected by a second pair of contacts placed slightly away from the original pair; the distance is about 0·022 in. Any potential encountered by the detector contacts is registered on a millivolt meter mounted on the end of the tongs. The present instrument is intended primarily for examining the ends of cold-rolled coils but an adaptation could be produced for scanning the full strip during rolling. Power is supplied by a 12 volt car battery.

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STAFF LOCATION

A Personal System

Many works have installed a system whereby members of the staff can be located when required. Some systems are visual and some audible, but many of them have a certain nuisance value to other workers.

A system has been evolved by the British Communications Corporation, Limited, Secondway, Exhibition Grounds, Wembley, Middlesex, by which only the person wanted knows of the call. The system is called the "Radiopage" and, as its name implies, utilises a radio distribution system. The members of the staff carry a pocket receiver set, one of which is shown in the illustration, and communications are sent out from a central control panel. The transmitter operates on a frequency band from 75 to 87 kc., allowing 50 channels with a spacing of 250 cycles. One channel is allotted to each of the receivers. The selector switch on the contro panel sets the carrier frequency for the receiver required, and a normal speech modulation is then imposed. The transmitters feed a loop of wire which encircles the building or buildings; normally this is run at ground-floor level and is simply attached to the walls by any convenient method. In most buildings this arrangement will be sufficient to give a coverage of from six to seven storeys in height, but where heavy steel framing has been used in the building it may be necessary to run an additional loop on another floor.

In order to reduce the power required of the transmitter, the loops in outlying buildings can be transformer coupled to the main loop and the coupling transformer would then feed a local amplifier. The loop may be constructed from any non-ferrous insulated wire providing that the total loop resistance does not exceed about 5 ohms. Under these conditions a transmitter with an output power of about 25 watts is probably sufficient for buildings covering between 20 and 30 acres. The transmitter may be installed in any convenient location within 100 ft. of the central control unit.

It is claimed for the equipment that, since it operates at comparatively low frequencies, external radiation from the building is negligible, and that sets can be used within a few yards of each other without mutual interference. It is also claimed to be free from interference from other electronic apparatus and equally that it itself will not cause interference in any other equipment or apparatus.

The receiver for the Radiopage staff-call system is carried in the pocket, and messages do not cause inconvenience to those not concerned.

In the receiver there is a crystal set at the chosen frequency for that particular unit, which is energised by the appropriate carrier frequency and closes the circuits within the receiver. Full use has been made of transistors and subminiature components, reducing the size required for the receiver and also its weight. Complete with battery, in a moulded case, the weight is just under nine ounces. The battery used is of the mercury type and is sufficient to give 500 hours operation.

The receiver measures 7⅜ in. by 2½ in. by ⅞ in. and has a built-in crystal loudspeaker with sufficient volume to be clearly audible without removing the set from the pocket. There are no controls on the receiver and when not carried in the pocket or deliberately propped in a vertical position it can only be laid flat, in which position a mercury switch within the set disconnects the battery. Signals are picked up by a Ferrite rod aerial mounted within the case. The system has been approved by the General Post Office and will only require a general licence for use. It has been installed in a hospital where the freedom from general disturbance is important and it is stated to be no more costly than many other location systems.

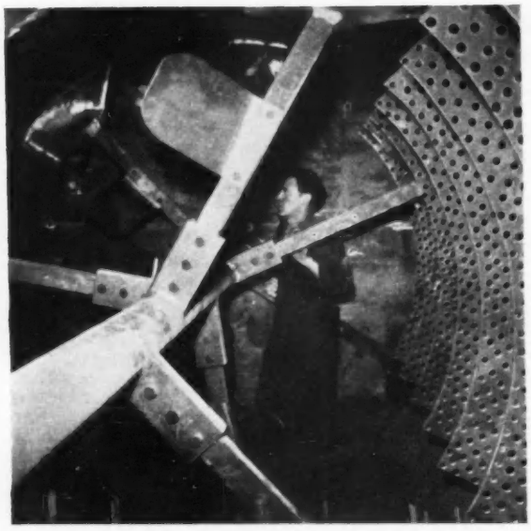

Fig. 1 Interior of the largest model of the Lödige-Morton precision mixing machine for pulverised, granulated or fibrous material. It has a working capacity of 3,740 gals. or 600 cub. ft.

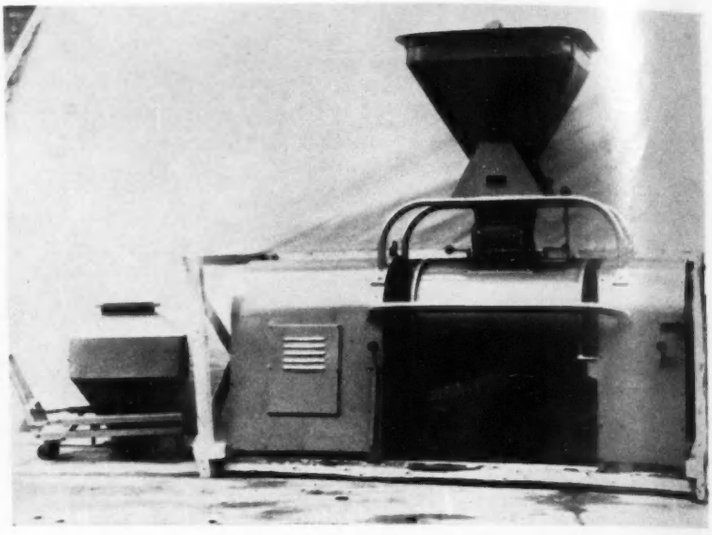

Fig. 2 Mixing machine with a capacity of 6½ cub. ft. The drum of this model rotates in the same direction as the mixing shovels but at a slower speed. Applications have been found in the pharmaceutical, plastics, food, metal and other industries.

PRECISION MACHINE FOR MIXING POWDERS RAPIDLY

A novel type of machine for the rapid mixing of pulverised, granulated and fibrous materials is now being produced by the Morton Machine Company, Limited, Wishaw, Lanarkshire. The machines have been designed and developed in Germany and the Scottish firm has entered into a manufacturing agreement to build them for the United Kingdom and all British Commonwealth markets.

The Lödige-Morton precision mixing machines, as they are called, range from one-quart capacity laboratory models to that shown in Fig. 1 above, which has a total capacity of 5,500 gallons (880 cub. ft.) and a working capacity of 3,740 gallons (600 cub. ft.). The machine consists essentially of a cylindrical mixing vessel having within it a set of revolving shovels mounted on arms attached to a central shaft. The shovels are double-plough shaped and designed in such a manner that the mix is thrown upwards and outwards, thus ensuring intermingling of the materials during their travel. This method enables materials of widely differing densities, such as iron powder and graphite, to be mixed efficiently. As the shovels pull the materials away from the inner surface of the vessel, the ingredients are not forced against each other or pressed down in a way which might destroy their particle size. It is claimed that owing to the special shape of the shovels fibrous materials which are particularly difficult to handle can be mixed with a minimum amount of damage. For certain types of mixes the cylindrical vessel, which is normally stationary, is made to revolve in the same direction as the shovels but at a slower speed.

WORKING IN FATS OR OILS

The shovel shaft is mounted on ball bearings and is sealed to prevent the mix from escaping from the container or dust from entering the ball races. The shaft is driven by an electric motor through V-belts and the shovels may be of mild or stainless steel. The reason for the adoption of the V-belt drive are two-fold, one being silence of operation and the other that this constitutes an inexpensive method of obtaining speed reduction. When the cylindrical vessel is rotated this is accomplished by means of chains driven from the shovel shaft. When particularly heavy materials are being mixed it is considered advisable to fit a centrifugal clutch to relieve the load on the V-belts, when starting up the machine. Additional equipment includes overhead sifting screens, and dust-proof filling and emptying containers. Perforated rubbing and grinding attachments can be fitted inside the cylindrical mixing vessel, as seen on the right in Fig. 1. The attachments are for working a liquid, oil or fat into a powder, the finished mix being discharged from the machine as a dry powder, with the liquid, oil or fat fully dispersed within it.

An average size machine is the M100D model, which is generally similar to that shown in Fig. 2, and has a total capacity of 25 gallons or 4 cub. ft., and an effective working capacity, at 60 per cent. filling, of 15·8 gallons or 2·5 cub. ft. Allowing two minutes for filling, a three-minute mixing time and two minutes for emptying, the capacity of the machine is 197·5 gallons per hour. The speed of rotation of the shovel shaft in this machine is 140 r.p.m. The net weight of the M100D model is 425 lb., the floor space required 3 ft. by 4 ft., and the horse-power needed 2 or 3. The machine shown in Fig. 2 is a somewhat larger model, designated FM300D, which has a working capacity of 6½ cub. ft. The horizontal guard rails seen are removable and the hand trolley on the left is used for emptying the contents of the cylindrical mixing vessel.

The Lödige-Morton machines have found successful applications in the pharmaceutical, plastics, food-preparation, metallurgical and other industries, and complex mixing problems have been simplified; in many cases the time taken for a mixing operation has been considerably reduced.

In the plastics industry, by fitting the rubbing and grinding attachments, stabilisers and other ingredients can be added, as well as colour pigments, solvents and fillers, to give a completely homogenous mix which, it is claimed, is free from streaks even when wax stabilisers are used. One interesting application is that developed for the mixing of polyvinyl chloride polymers, fillers and a plasticiser to a dry powder in the presence of heat. The resultant mix is fed directly into a cable extruding machine. Two sizes of mixing machine are available for this work, capable of handling 300 lb. and 1,400 lb. per hour, respectively. They are supplied with a jacket for steam or hot-oil working up to a temperature of 150 deg. C., and the mix is discharged into a water-cooled container placed under the hot vessel.

MATERIALS FOR SINTERING

A difficult mix is that concerned in the preparation of a material for sintering, involving graphite and iron powder in proportions of 30 or 40 : 1. In a European steelworks eight Lödige machines are now at work on this mix and it is stated that, despite the substantial difference in the density of the two materials, 100 per cent. mixing precision is obtained in eight minutes.

In the food industry the machines are employed in the preparation of such products as cake mixes, fish and meat pastes and custard powder. They are also used in the manufacture of cattle-cake and other types of animal food, and in the production of mineral salt and of carbon employed as a filtering medium. In order to help organisations interested in this type of equipment we are informed that the Morton Machine Company have established facilities for carrying out experimental mixes.

LEVERHULME RESEARCH AWARDS

Among the fellowships approved by the trustees of the Leverhulme Research Awards for 1956, are one to Dr. E. G. Richardson, reader in physics at the University of Durham, for the study of "The Propagation of Sound in a Turbulent Medium," and another to Mr. R. A. Skelton, superintendent of the map room, British Museum, for work on "The Foundation and Early History of the Ordnance Survey, 1782-1825."

Research grants have also been made to Dr. R. F. Barrow, Fellow of Exeter College, Oxford, for "Studies in the Spectroscopy of Simple Molecules," to Mr. A. R. Bailey, Turner and Newall Research Fellow, Imperial College, London, for research on "The Intercrystalline Cracking and Failure of High-Tensile Brass"; and to Mr. H. Thomas, assistant buildings officer, University of Manchester, for a study of "The Application of Architectural Acoustics to the Design and Construction of Schools for the Deaf."

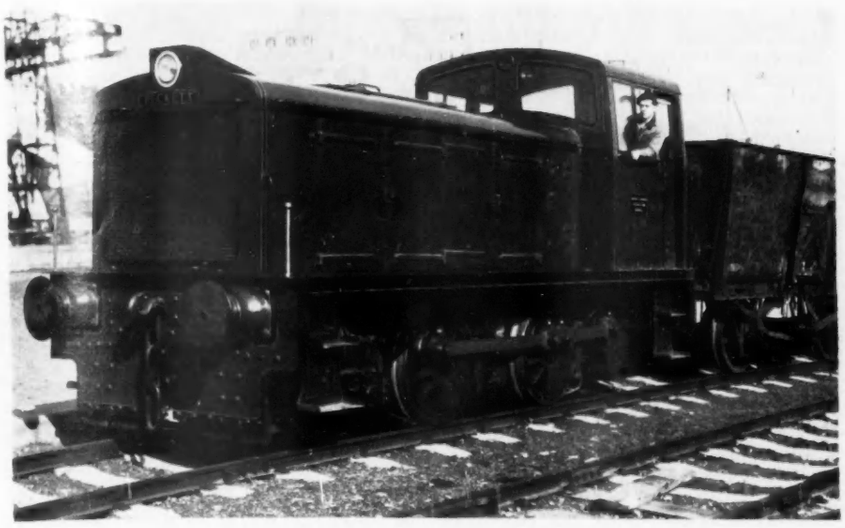

Fig. 1 Designed for industrial shunting the Peckett 200 h.p. Diesel-mechanical locomotive can give a tractive effort in bottom gear of 19,000 lb.

DIESEL-MECHANICAL LOCOMOTIVE

AUTOMATIC GEAR CHANGE SIMPLIFIES CONTROL

Two prototypes of a Diesel-mechanical locomotive designed primarily for industrial shunting have recently been completed by Peckett and Sons, Limited, at their Bristol works. For what is believed to be the first time a fully automatic mechanical transmission has been developed for locomotive work; it offers the ease of control of an electric or hydraulic system coupled with a high transmission efficiency and simple robust parts.

The locomotive, which is nominally of 200 horse-power and has a total weight of 32 tons, is 20 ft. 4 in. in overall length, 11 ft. 3 in. high and 8 ft. 6 in. wide. It has an 0-4-0 wheel arrangement and a wheelbase of 5 ft. 6 in., which allows it to traverse a minimum curve of 50 ft. radius. The wheels, which are 3 ft. 2½ in. in diameter, are driven by connecting and coupling rods from a jackshaft at the rear end. Models can be built to run on standard 4 ft. 8½ in. track or on tracks ranging from a metre to 5 ft. 6 in. It is also anticipated that six-coupled versions will be produced for operating on light tracks, where the permissible axle load is limited. These modifications will require no major alteration to the locomotive. The bonnet has four access doors on each side and large double doors in the roof for engine maintenance. As can be seen from Fig. 1, a clear view is obtained from the driving positions, both over the bonnet and to the rear.

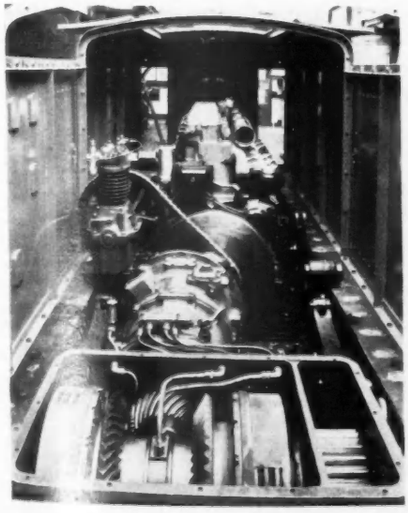

Fig. 2 ...iew of locomotive interior showing engine ... compressor, transmission system and clutchi... ...evel-gear reversing unit. The transmissio... ...vides automatic gear change controlled hydrau... ...y by a governor, with four speeds forward and reverse.

INDUSTRIAL SHUNTING

The locomotive has a top speed of 13¾ m.p.h., which is quite sufficient for most industrial shunting. The bottom gear tractive effort is approximately 19,000 lb. There are four gear ratios, 4 : 1, 2·54 : 1, 1·57 : 1, and 1 : 1, with a final drive ratio of 10 : 1 from the gearbox to the rail wheels. These ratios can, of course, be varied to suit particular applications, with corresponding variations in the maximum speed and tractive effort. All four ratios apply to forward and reverse. The two prototype locomotives differ in that one is fitted with a Gardner type 8L3 engine developing 204 b.h.p. at 1,200 r.p.m., and the other with a Crossley type EST 4 developing 220 b.h.p. at 750 r.p.m. By means of a different ratio in a pair of transfer gears, the input shaft of the gearbox is in both cases driven at a maximum speed of 1,200 r.p.m. In all other respects the two locomotives are similar. The design has been arranged so that other well-known makes of Diesel engine can also be accommodated.

The four-speed automatic gearbox has been developed by Hobbs Transmission Limited, of Leamington Spa, in conjunction with Peckett and Sons Limited. In general principle, it is similar to Hobbs transmissions fitted to road vehicles and to certain armoured fighting vehicles and heavy earth moving equipment, though the present application differs considerably in detail. This unit will be described in a later issue of ENGINEERING. (It has industrial as well as traction applications.) The arrangement of the transmission and other equipment can be seen in Figs. 2 and 3.

Control of the engine is achieved by two levers only, the throttle and the reversing lever, since the gear changes are automatic. Only two other controls are necessary for driving the locomotive —the air-brake valve and the sanding valve— making a total of four, all of which are duplicated on each side of the cab. Instruments have been reduced to a minimum in the interests of simplicity and the number of protective devices has been limited to facilitate maintenance. A twin-cylinder Broom and Wade air compressor provides air for the Westinghouse air brake, and also for the horn and sanding gear.

The design of the gearbox enables an overriding manual gear lever to be fitted, which will give positive engagement of first, second or third ratios. This may be of value in specialised applications, for example, where it is desired to use the resistance of the engine to control a load down long gradients. In the case of a manual change it is only necessary to move the lever to the ratio desired; the actual changing is then accomplished by the various parts of the hydraulic circuit in exactly the same manner as an automatic change. Power is transmitted from the engine to the gearbox by a Layrub flexible coupling.

REVERSING

Reversing is accomplished by clutching in alternative spiral-bevel gears in the final drive, by means of hydraulically operated clutches. They are interlocked with the gearbox so that engagement or release can only occur when the engine is at idling speed. It is not necessary,

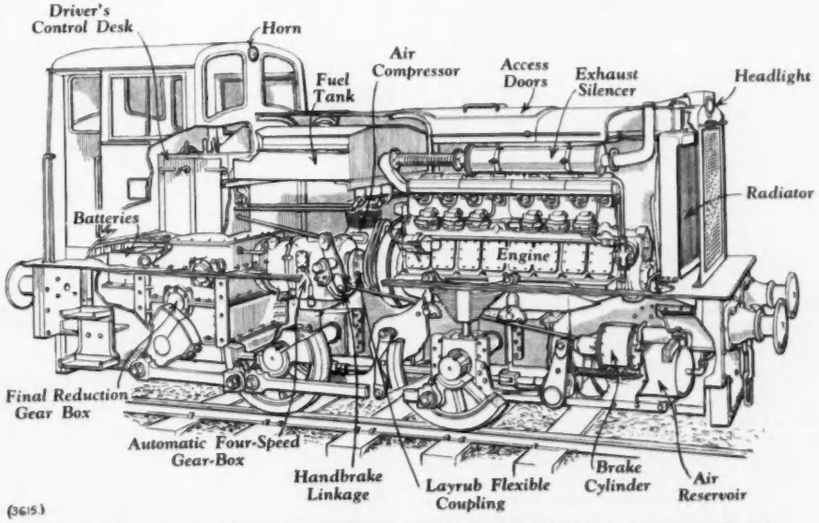

Fig. 3 Arrangement of 200 h.p. locomotive showing layout of engine and other equipment.

however, for the locomotive itself to be completely at rest when reversing, so that a rapid change of direction can be accomplished. In addition to the bevels and reversing clutches, the final drive box contains double reduction spur gearing, with the final gearwheel mounted on the jackshaft.

The plate frames are rigidly braced by cross stays and a substantial racking plate which runs from the front of the locomotive to the forward end of the final drive box; this is bolted directly between the frames and itself forms a stiffener of great strength. The engine is rigidly mounted on a fabricated sub-frame assembly which is bolted to the racking plate. Plain axleboxes are employed, having overhung springs mounted inside the frames. The fuel tank of 220 gallons capacity is mounted under the bonnet just forward of the cab. Warming radiators using the engine cooling water add to the driver's comfort.

The primary considerations in designing these locomotives have been simplicity, robust construction and easy maintenance, to be achieved at moderate cost. The design can be readily adapted for a variety of applications in addition to industrial shunting. At the present time two smaller versions of 100 horse-power and 150 horse-power are under development, and it is intended to extend the range upwards.

Apart from items already mentioned, components have been supplied by: Alfred Wiseman and Company, Limited (final drive box); Westinghouse Brake and Signal Company (air-brake gear, sanding gear and horn); C.A.V. Limited (starter and dynamo); Exide (battery); and Reliance Radiators, Limited (radiator).

PRODUCTION EXHIBITION

During the past nine days, from May 23 to May 31, the second Production Exhibition, organised by Andry Montgomery, Limited, 32 Millbank, London, S.W.1, in co-operation with the Institution of Production Engineers, has been held at Olympia. Concurrently with the exhibition, a conference has taken place on the theme "Investing in Success," with discussions on international co-operation for productivity, research, automation, atomic energy, fuel utilisation, factory design and layout, designing for production, machine tools, quality control and inspection, simplification and standardisation, work study, materials handling, utilisation of resources, education and training, and human relations.

The purpose of the Production Exhibition, which is not primarily a "trade show," was to demonstrate, to management and to labour, how industry can best make use of available manpower, materials and machines—a problem of urgency for the United Kingdom, which is lagging behind the United States, Canada, Sweden and Switzerland in productivity. Essential steps in increasing productivity, all of which were represented in the exhibition, are education and training of workers and management at all stages; research and development; work study; standardisation; manpower; methods of manufacture; aids to production; automation; choice of materials; and design for production.

The use of research as a tool for increasing productivity was the theme of the Department of Scientific and Industrial Research stand, on which were displayed a diversity of products and processes developed by various firms, both of medium and small size, and all with a different approach to the research problem; while some have conducted their own researches, others have used the resources of the government research departments and co-operative research associations; in some cases technical periodicals and patent searches laid the foundation of development, while one firm derived inspiration from the Skylon of the 1951 Festival of Britain exhibition for developing a stool for factory workers with a suspension system designed to reduce body tension and fatigue.

TRAINING FOR MANAGEMENT

Among the exhibits on education and training may be mentioned the scheme of Thomas Hedley and Company, Limited, Newcastle-upon-Tyne, for training graduates for management responsibility. The training course lasts six months, and from the start the graduate plans his own work in a series of graded assignments, familiarising himself with the process and equipment, the people on the job, and the administration.

The exhibit of the British Motor Corporation, Limited, Cowley, Oxford, which showed in model form the wide extent to which mechanisation has progressed in the automobile industry, was planned and progressed by production-engineering apprentices of the Austin Motor Company. Trade apprentices of the company assembled the models and prepared the display, the central item of which was an illuminated and animated representation of car production and assembly lines. Flashing lights showed how the production programme is fed into an E.M.I. electronic production control unit which issues instructions to production lines through a time-delay unit so that various components reach the final assembly lines at the required time.

Other working-model exhibits on this stand included a twelve-station straight-line transfer machine; the Rotodip plant in which car bodies receive their rust-proofing and initial paint treatment, at a rate of 22 bodies per hour; a multipl-track electronically controlled sequencing conveyor; a running-in unit in which the crankshafts of complete engines still moving along the assembly track, are rotated by electric motors for 17 minutes; Ransburg electrostatic paint spray plant, supplied by Henry W. Peabody (Industrial), Limited, 17 Great Suffolk-street, London, S.E.1, which reduces wastage resulting from "overspray"; and a photo-electrically controlled automatic spray paint.

AUTOMATION AND DATA PROCESSING

Electronic machine-tool control was demonstrated by E.M.I. Electronics Limited, Hayes, Middlesex, who have already installed two such systems in users' factories—one at Laurence, Scott and Electromotors, Limited, Norwich, applied to a precision copymill made by Research Engineers Limited, described in ENGINEERING for December 2, 1955, page 769, and one with Bristol Aero Engines Limited, applied to a Cincinnati vertical miller.

A limited amount of information regarding the dimensions of the finished part is fed into the control unit in the form of punched paper tape. The control unit works out the ancillary information needed, and controls the machine automatically while it cuts the required shape.

Punched tape for communication and control was the theme of the exhibit of Creed and Company, Limited, Telegraph House, Croydon, Surrey. Equipment for "control" applications, such as data processing and automation, includes a new perforating typewriter which produces punched tape at speeds up to 200 words a minute simultaneously with a normal typewritten copy; tape checking by a new tape verifier which examines a "suspect" tape and produces a second error-free tape; and tape reading at 800 characters per minute by a multi-head tape reader, and the automatic recording of data in punched-tape form at the high speed of 25 characters per second by the new Model 25 high-speed re-perforator, together with the subsequent reproduction of such data in printed page form by Model 54 page teleprinter receiver.

The British Tabulating Machine Company, Limited, 17 Park-lane, London, W.1, demonstrated the use of punched cards and the Hec electronic computer for reducing clerical effort in production control procedures. The company formed, some two years ago, a Production Control Department to formulate a picture of the difficulties likely to be encountered when mechanising production-control procedures, either on punched card equipment or with a Hec electronic computer. Research carried out by this team has enabled them to evolve mechanised techniques, dealing with the whole field of technical and clerical procedures. The exhibits showed in some detail the procedures involved, using simplified flow charts covering planning and scheduling, raw-material control, and plant and labour loading. Examples of the amount of detail available in the final computer tabulations—and the technique noting only those facts which require immediate action—were displayed.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

OXFORD
Annual General Meeting. Oxford, Reading and District Branch. Y.M.C.A., 10 George-street, Oxford. Sat., June 2, 7 p.m.

Building Centre

LONDON
Films illustrating Tiger V and Wolf IIIb excavators. Wed., June 6, 12.45 p.m.

Chemical Society

LONDON
Centenary Lecture on "The Present Status of the Trans-uranium Elements," by Professor G. T. Seaborg. Thurs., June 7, 7.30 p.m.

LIVERPOOL
Centenary Lecture on "The Present Status of the Trans-uranium Elements," by Professor G. T. Seaborg. Chemistry Lecture Theatre, The University, Liverpool. Tues., June 5, 5.30 p.m.

Institute of Metals

LONDON
"Some Recent Studies of Irradiation Effects in Metals and Other Solids," by Professor R. Smoluchowski. Institution of Naval Architects, 10 Upper Belgrave-street, S.W.1. Wed., June 13, 6.30 p.m.

Institution of Civil Engineers

LONDON
Annual General Meeting (Corporate Members only). Tues., June 5, 5.30 p.m.*

Institution of Mining Engineers

EDINBURGH
Summer Meeting:
"Problems of Coal-Face Mechanisation in the Scottish Coalfield," by Dr. J. H. Paterson and H. H. Wilson, at 11 a.m.
"A Study of British and Continental Methods of Colliery Blasting," by R. F. McCormick and Dr. R. Westwater, at 2.30 p.m. Freemasons' Hall, 96 George-street, Edinburgh 2. Wed., June 20. Various visits and excursions. Thurs. and Fri., June 21 and 22.

Institution of Naval Architects

LONDON
"The Planing Performance, Pressures and Stresses in a High-Speed Launch," by Commander P. Du Cane, R.N. Thurs., June 7, 4.45 p.m.*

Institution of Production Engineers

PETERBOROUGH
One-day conference on "Aspects of Automation." North Midlands Regional Meeting. At works of F. Perkins, Ltd., Peterborough. Sat., June 2, 10 a.m.

Royal Meteorological Society

LONDON
"The General Circulation of the Atmosphere: A Numerical Experiment," by N. A. Phillips. Wed., June 20, 5 p.m.*

Royal Society of Arts

LONDON
"The Influence of National Character on Design," by Paul Reilly. Wed., June 6, 2.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceeding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Mining Engineers, 3 Grosvenor-crescent, London, S.W.1. (BELgravia 3691.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 07[illegible], London.
Royal Society of Arts, John Adam-street, [illegible], London, W.C.2. (TRAfalgar 2366.)

TELEVISION AS AN AID TO BOILER CONTROL

PERISCOPE EQUIPMENT FOR FURNACE OBSERVATION

The observation of furnace conditions tends to become more difficult as the size of boilers, especially the large pulverised-fuel units which are now being installed in power stations, is increased. The combustion chambers can no longer be inspected from one, or even two, levels and a tour of inspection may take as much as half an hour. Moreover, the plain mirror periscope, which has been in use for this purpose for many years, has its limitations when remote control of the boilers is installed, while with pulverised-fuel firing it is important that a close watch should be kept on combustion conditions. Finally, when pressure firing is adopted, so that the furnace operates under forced rather than balanced draught, the inspection doors must be small and must be arranged for operating under pressure, utilising an air blast "curtain" for protection.

These considerations have led to the development of periscopic television equipment by Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, in conjunction with the British Iron and Steel Research Association, Marconi's Wireless Telegraph Company, Limited, Chelmsford, and the Foster Instrument Company, Limited, Letchworth. This equipment, which has been installed on a 400,000 lb. pulverised fuel-fired boiler at Barking C power station, incorporates optical principles which enable the whole of the burner wall and the burners themselves to be observed from a single position, and to be televised thence to any part of the station.

COMPLETE WALL IN VIEW

The optical system used, which is shown diagrammatically in Fig. 1, consists of an arrangement of filters, image forming lenses a and a_1, prisms b and b_1, and field lenses c and c_1, upon which light from the furnace impinges through the apertures d and d_1. On emerging from the field lenses the light next passes through the objective lens e and falls on the eyepiece f, from the outlet of which it passes to the television camera. It is transmitted thence to a monitor screen, where the furnace conditions can be viewed.

As will be seen, the periscope is of the panoramic type with twin entrance apertures, the lenses and prims b and b_1 and c and c_1 being so arranged that two fields of view are combined with a dividing line at the centre of the picture. A field of 90 deg. in one plane and 45 deg. in the other can easily be resolved, thus allowing a complete burner wall to be observed from a position above the burners.

PANORAMIC PERISCOPE

The periscope, which is completely water-cooled and is also provided with an air blast arrangement to prevent fly ash from settling on the emission of gas or flame. Actually the unit can safely be inserted or withdrawn against furnace pressures up to 20 in. water gauge.

TELEVISION CAMERA

The camera is of the standard Marconi industrial type which measures 5¼ in. by 4 in. by 8½ in. and weighs only 4½ lb. It incorporates a Vidicon pick-up tube, the signal from which is capacity-coupled to a three stage video amplifier and fed thence to a mixer stage. In this circuit the outputs of the vision and synchronising pulse circuits are combined, and the resultant signal is further amplified. This combined signal is then fed through a clipper stage which keeps the horizontal and vertical synchronising pulses equal in amplitude regardless of varying signal conditions. Stable monitor synchronisation is thereby maintained. An earthed-cathode

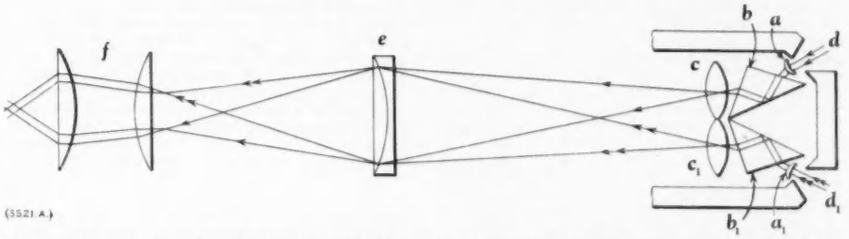

Fig. 1 Diagram of periscopic system installed on 400,000 lb. pulverised fuel-fired boiler at Barking power station for the observation of furnace conditions.

a and a_1 Image forming lenses. b and b_1 Prisms. c and c_1 Field lenses. d and d_1 Entrance apertures. e Objective lens. f Eyepiece

the lens windows, is mounted on the pneumatically operated carriage illustrated in Fig. 2. This carriage can be advanced or withdrawn from the furnace by a Martonair remote-controlled air cylinder. The television camera is also mounted on the carriage and is visible on the extreme right of the illustration.

When applied to a pressure-operated furnace the nose of the water jacket of the periscope is provided with a conical fairing, which can be seen on the left of the illustration, to ensure that the flow of air in the 4 in. air blast door through which the unit enters the furnace is not interfered with. The door itself consists of gas-tight flaps, which are pushed open by the nose of the periscope as it advances, while simultaneously high pressure air is automatically admitted to a ring of nozzles which converge on the opening round the door. The velocity of these jets is high enough to induce air into the furnace and to form a "curtain," which prevents

Hartley oscillator circuit provides any frequency between 54 and 58 megacycles, which is modulated by the vision signal. This modulated signal is then fed through a coaxial cable to the control unit.

The control unit contains the horizontal and vertical deflection circuits for the pick-up tube and a circuit which prevents the burning of the video target coating in event of scanning failure. It also includes circuits for providing the necessary wave forms for vertical and horizontal scan, vertical and horizontal blanking and synchronising pulses. Its power consumption is 100 watts at either 100 to 117 volts or 200 to 250 volts.

SAFETY PRECAUTIONS

The periscope which has just been described, is normally used only during lighting up. Under stable operating conditions it is withdrawn and monitoring is effected by a photo-electric cell. Should the overall brightness of the furnace then decrease, this cell operates an alarm on the control panel and the periscope is automatically advanced into the furnace, so that the burner which has been extinguished is shown on the screen of the monitor. Interlocks are provided to ensure that the periscope cannot be advanced into the furnace unless both compressed air and water supplies are available and is withdrawn should either of these services fail.

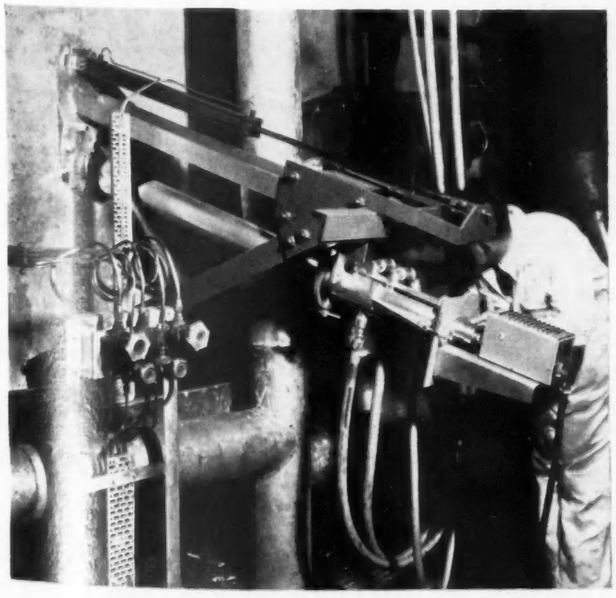

Fig. 2 View of the periscope unit showing cooling arrangement and television camera whereby the furnace conditions can be remotely viewed.

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ELECTRICITY SUPPLY FOR APRIL

Increase Maintained

Once again the national figures for electricity show an increase over those for 1955—those for April, 1956, are 13·6 per cent. greater, a figure which is reduced to 8·2 per cent. (the same as for February) when corrected for weather and the number of effective working days. The total number of units sold by the Central Electricity Authority was 5,812 million kWh.

Of this total, the Area Boards sent out 4,640·6 million units and the remainder was supplied direct from the C.E.A. "Mainly industrial" showed an increase of 11·4 per cent. and "mainly non-industrial" one of 16·9 per cent. over the corresponding figures for last year.

ATOMIC REVIEW

M.I.T. and Princeton to build large accelerators—Bubble chamber for viewing tracks of nuclear particles—First Calder Hall reactor becomes critical—Details of Soviet atomic power station plans and a nuclear powered ice-breaker—U.S. A.E.C. issues licences for private atomic power station construction—Ceramic uranium carbide reactor fuel—Reactor research.

As in the previous Atomic Review, abstracts of United Kingdom Atomic Energy Authority and other reports may be recognised by the official reference classification inserted after each item.

Accelerators and Particles

The Massachusetts Institute of Technology and Harvard University are jointly to design, build and operate a 6GeV (G = 10^9; in U.S.A. B = 10^9) electron synchroton to be called the "Cambridge Electron Accelerator." The unit, which will be a circular alternating gradient electron synchroton 236 ft. in diameter, is to be completed in about four years. Sixteen radio-frequency circuits will serve to accelerate the electrons, which will be guided round the orbit by 48 laminated magnets, each measuring 2 ft. by 2 ft. by 11 ft. The machine will be used for fundamental research in particle physics. Though it will be, as far as is known, the highest-energy electron accelerator, it will not be as powerful as the proton synchroton now being built at the Brookhaven National Laboratory, New York, which will accelerate protons to energies of 25 to 30 GeV. The University of California's "Bevatron," which is already in operation, has a power of 6 GeV.

Another machine is to be constructed at Princeton, New Jersey, and will be used by Princeton University and the University of Pennsylvania. This will be a 3 GeV uniform gradient proton synchroton, resembling the cosmotron at Brookhaven National Laboratory but with a higher beam intensity. The main element of the machine will be an alternating-current electromagnet 80 ft. in diameter and weighing 400 tons. One purpose for which it will be used is the investigation of heavy mesons.

High energy accelerators are also being built in the Soviet Union. One which is believed to have recently been completed will give particles of between 10 and 12 GeV; in addition, a proton accelerator having a power of 50 to 60 GeV is being planned. Machines under construction at the CERN Laboratory in Geneva will operate at 600 MeV and 25 GeV. Articles describing high powered accelerators have recently appeared in ENGINEERING (vol. 180, pages 340, 374 and 530, 1955).

The design of a Cerenkov counter for the proton synchroton at Birmingham University has been described in an AERE report. It is a development of an early design due to Getting. The detector has an optical efficiency far exceeding those of detectors previously used on accelerated proton beams, while estimates of the overall resolution indicate that the instrument is only slightly inferior in this respect to other designs. There are certain practical considerations in applying the design to the Birmingham machine, in relation to the low flux of particles, the low repetition rate, and the pulse characteristics of the external proton beam. A vacuum photocell may be used in place of a photomultiplier. (J. V. Jelley, AERE NP/R. 1770.)

BUBBLE CHAMBER

A new technique for observing the paths of nuclear particles has recently been described in *The Times Science Review* by Mr. J. McKenzie, of the Cavendish Laboratory, Cambridge. Methods in current use are the familiar Wilson cloud chamber and the basically similar one of recording the particle tracks directly in the emulsion of a photographic plate. The new method is in a sense a reversal of the cloud chamber, for the tracks are not recorded by the condensation of a vapour but by the formation of bubbles in a superheated liquid, which though above boiling point only vaporises as the particle passes through it. Liquid hydrogen, ethane, propane and other materials have been used as the superheated liquid and the technique is expected to yield useful results in the near future. The originator of the idea was Dr. D. A. Glaser, of the University of Michigan and it has been developed in its present form by Professor L. Alvarez of the University of California. The illustration above shows tracks of nuclear particles in liquid hydrogen; the key indicates possible events represented by the tracks.

Reactors for Power and Propulsion

Probably the most important recent event in the field of atomic energy occurred on May 22 when the first of the two reactors at the Calder Hall power station became critical. Calder Hall is likely to be the first full-scale atomic power station in the world to generate electricity. Physical measurements and instrument checks are now being made and the gradual commissioning of the plant will follow. Her Majesty the Queen is to perform the official opening of the station on October 17.

There has been some doubt as to the extent of the Soviet atomic power programme owing to a failure by the Soviet authorities to distinguish between reactor heat output and electrical capacity. However, in the hope of forming a clearer picture we give below a direct translation of Academician I. V. Kurchatov's remarks on the subject, made at Harwell some weeks ago.

"We aim to develop atomic power production which in the conditions of the European part of the U.S.S.R., at least will be more economical than coal power. To this end we plan to build in the early period large atomic electric power plants of 400,000 to 600,000 kW to accumulate experience in nuclear engineering and mass production of fuel elements and their processing. Atomic power can be economically produced only at large atomic power plants. The construction of such plants and their operation will also make it possible to determine which of the installations are safest for the surrounding population. The economic characteristics and these data will determine the type of atomic power stations and the scale of atomic power development in the 1960-1970 period.

SOVIET PLANS

"In the 1956-1960 five-year period, we plan to build five experimental atomic power stations. According to this programme the atomic power stations will be put into operation beginning with the end of 1958; some of them will start operation in 1959 and 1960. Two stations will be equipped with water-modulated and cooled thermal and epithermal 200,000 kW reactors, and 70,000 kW turbines using saturated steam of about 30 atmospheres pressure. Another station will be equipped with graphite-moderated steam and water-cooled reactors of the type used at the first atomic power plant of the U.S.S.R. Academy of Sciences, on which a paper was read at the Geneva Conference by Professor Blokhintsev (ENGINEERING, vol. 180, page 233, 1955). Each reactor will produce steam at about 90 atmospheres, superheated to 480 to 500 deg. C. for feeding turbines of 200,000 kW total capacity. The third type of atomic power plant will have a heterogeneous heavy water-moderated and gas-cooled reactor. It will produce steam at about 30 atmospheres, pressure, with a temperature of some 400 deg. C. for feeding turbines of 200,000 kW total capacity.

"Besides these three types of large atomic power plants, we shall build and put into operation in 1959-60 several pilot plants each with an electrical capacity of 50,000 to 70,000 kW. These will include: 1. a unit with a water-moderated thermal reactor and a turbine operated by slightly radioactive steam fed directly from the reactor; 2. a homogeneous heavy water-moderated thermal-breeder reactor, with the uranium 233-thorium 232 cycle; 3. a thermal graphite-moderated and sodium cooled reactor; and 4. a fast sodium-cooled breeder reactor with the plutonium 239-uranium 238 cycle." (See article, "Atomic Speculation.")

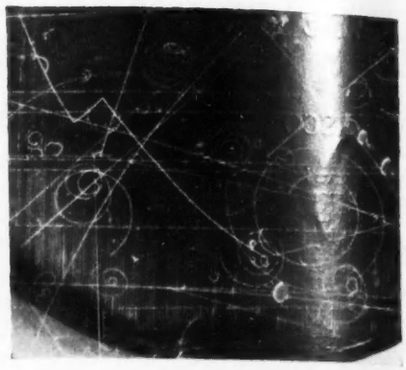
Czechoslovakia has also announced that an experimental nuclear power station with an initial capacity of 150 MW has been proposed in a new Five-Year Plan.

In a recent interview published in *Izvestia*, Mr. E. P. Slavsky, chief of the Soviet atomic energy administration, has expressed his confidence in the development in the near future of an atomic powered aeroplane and given details of a reactor-driven ice breaker already under construction. The vessel is to be of 16,000 tons displacement, fitted with engines developing 44,000 h.p. and capable of 18 knots.

CERAMIC URANIUM FUEL

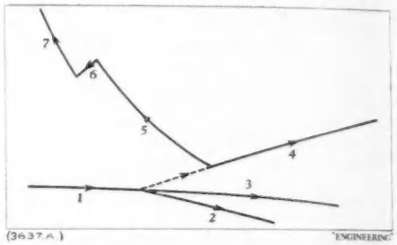
During May, the U.S. Atomic Energy Commission issued the first two licences for private construction of nuclear power stations. The Consolidated Edison Company of New York received a licence to build a 140,000 kW. pressurised converter thorium reactor. Babcock and Wilcox are responsible for its construction and it is scheduled for completion by October, 1960. The General Electric Company are the contractors for a 180,000 kW boiling-water reactor to be built under a licence issued to the Commonwealth Edison Company of Chicago. The reactor is expected to begin trial operation in July, 1960. Other private projects planned have a total capacity of 1,100 MW.

A reactor plant driving a gas-turbine through a closed cycle, and using ceramic uranium carbide as fuel, has been proposed in the United States. The plant would combine the advantages of solid fuel and high operating temperatures, these being in the region of 1,200 deg. C. A small reactor could therefore produce between 10 and 15 MW of electricity. The outer casing of the reactor might be made of hafnium carbide, which remains unmelted up to about 3,900 deg. C., while various structural members would be made of other ceramic materials.



Tracks of nuclear particles left as bubbles in superheated liquid hydrogen in a 10 in. bubble chamber. Events suggested in key below.

(Original photograph taken at the University of California and published by courtesy of Mr. J. McKenzie of the Cavendish Laboratory, Cambridge.)



Key to the most striking sequence of tracks in the accompanying illustration. There appear to be four successive events which may possibly be described as follows: a π^- meson (1), of 273 electron masses, strikes a proton, scatters it (2), and produces a K^- meson (3), of 966 electron masses, and a neutral θ^0 meson, also of 966 electron masses. The neutral meson leaves no track and is shown dotted. It decays into a π^- meson (4) and a π^+ meson (5). The π^+ meson stops in the hydrogen and decays into a μ^+ meson (6), of 207 electron masses, which remains in the hydrogen and decays into a positive electron (7), which passes through the top glass of the chamber.

Reactor Research

The Swedish Atomic Energy Company has applied for a State grant of S.kr. 36·5 M for the budget year 1956/57. Capital expenses include the construction of the second experimental reactor and the cost of preparing fuel material. Experiments and developments in recent years have suggested that it may be possible to reduce prices for the production of uranium by the Swedish method from her own low quality ores by improving methods and increasing the scale of operations, and the company is continuing prospecting for other deposits. (R. G. Silversides. Scandinavian I/N. D.S.I.R.) The Rensselaer Polytechnic Institute at Troy, New York, have announced completion of a 30 ft. deep "swimming pool" reactor for research purposes, and the Massachusetts Institute of Technology is to build a heavy-water research reactor at Cambridge, Mass., based on the Argonne CP-5 plant.

FISSION PRODUCT GASES

An investigation of fission product gases has been carried out and their characteristics determined. The activity, heat release and weight of the fission product gases and their daughter products which will be removed from a 140 MW reactor has been calculated and results are given. The way in which these results can be applied to other reactor power levels is indicated. (P. C. Davidge and C. J. L. Lock. AERE C/M 262.)

A value for the temperature coefficient of homogeneous spherical reactors has been obtained. The temperature coefficient (defined as $\frac{1}{K_e}\frac{dK_e}{dT}$, where K_e is the effective multiplication constant) is derived as a function of changes in the nuclear constants and reactor size for a spherical homogeneous reactor with an infinite reflector. It is assumed that the temperature changes in the core and reflector are the same, and that the moderating materials in the core and reflector. (C. C. Horton. AERE RP/M 65.)

ATOMIC SPECULATION

The game of speculation on inadequate information has a fascination much like the pleasure of unravelling a detective story plot or reconstructing ancient civilisations on meagre archaeological evidence. The man outside the security fence is sometimes tempted, perhaps rashly, to play this game with atomic energy. Almost always he will find an essential item of information missing and will be compelled to resort to guesswork in order to complete his picture.

CONFLICTING SOVIET FIGURES

A good example is the Soviet announcement concerning their proposed atomic power station programme. In Mr. N. A. Bulganin's report to the 20th Congress of the Communist Party of the Soviet Union, he stated in a section covering work planned for completion by 1960, immediately after some figures for the electrical generating capacity of projected orthodox power stations: "A noteworthy feature of the Sixth Five-Year Plan will be the broad construction and utilisation of atomic power stations. The draft directives propose the building of several atomic power stations with a total capacity of 2 to 2½ million kilowatts, which is about one and a half times as great as the capacity of the power stations whose construction was envisaged under the famous GOELRO plan." Mr. D. G. Zhimirin, first deputy chairman of the State Planning Commission, has since confirmed that this figure represents the proposed atomic power station capacity to be achieved by 1960.

Now the figures given by Academician I. V. Kurchatov (see "Atomic Review") suggest, if it is assumed that one power station has no more than two reactors, that the total electrical capacity to be installed by 1960, will not exceed 800 or 900 MW. Furthermore, since this is an experimental programme it would be unwise to carry it out on a very great scale. Does this mean that Mr. Bulganin was speaking in terms of reactor heat capacity? This seems unlikely since the 2 to 2½ million figure is compared with corresponding figures for orthodox power plants. It would surely be ridiculous to set reactor heat output beside calorific value for coal and oil burning stations or the potential energy of water for hydro-electric stations. How are these conflicting estimates to be reconciled? Can it be that Mr. Bulganin's figures were compiled from various sources by a non-technical layman, who was unable to distinguish between reactor heat capacity and electrical output? Or is it that an attempt has been made to confuse the foreign observer?

In any case, but particularly if Mr. Bulganin's figures are accepted, the extent of the Soviet proposals is interesting, since we cannot assume that shortage of coal has provided the impetus for rapid development, as it has in this country. It remains to be supposed either that nuclear fuels are abundant in the Soviet Union, that plutonium is to be produced on a large scale, or that the cost of transporting coal is high. It does in fact appear from other remarks made by Academician Kurchatov that although energy resources in Siberia are large, in the European part of the U.S.S.R., where most of the Soviet Union's population and industries are concentrated, coal is likely to become increasingly scarce and transportation costly. A last possibility is that the Soviet Union, being a comparatively late starter in the industrial field, has chosen from now on to develop its electricity supply system mainly on a nuclear basis. This may be compared with architecture in Japan or Venezuela where the buildings are much more modern than ours, or transport in West Africa where roads are few and poor but internal air services extensive.

HOT REACTORS

The casual reader might expect that in Britain, atomic energy matters would be less clouded in security. But he would be mistaken. It is almost as difficult to see through the chicken wire round Harwell as through the now slightly perforated iron curtain, though perhaps the recent Open Days herald a more indulgent era. Again it is necessary to resort to speculation. It can be fairly certain, for instance, that work is being carried out in the United Kingdom on high-temperature reactors using molten metal or metal slurry fuels, as it is in the United States, but unless we discover that someone has completed some apparently academic research on flow and heat transfer problems in liquids exhibiting spontaneous internal heat generation, we must take it on trust.

Small advertisements in this paper and the daily Press are sometimes helpful, but these could no doubt be very misleading since they are probably composed to get away as little as possible. Recently, for instance, Harwell was advertising for Scientific Officers to work in a group engaged on research into novel methods of particle acceleration, in particular, methods capable of producing high beam intensities. Initial work being carried out on model magnets and accelerating systems is expected to provide information upon which to base the design of a new machine." Since the Atomic Energy Research Establishment performs research generally with some practical object in view, and since accelerators are mainly used for fundamental research, it might be guessed that construction of a high-powered machine was envisaged for thermonuclear studies. As has previously been pointed out, hydrogen fusion reactions might be initiated in several ways; apart from methods employing pulsed electric currents through gases and shock waves caused by small explosions, particle accelerators could be used to give the high temperatures required (about a million degrees C.).

The great practical value of accelerators is illustrated by the immense amount of money the Soviet authorities seem prepared to spend on them. However, it would be very rash indeed to jump to the conclusion on this evidence that the U.K.A.E.A. were planning investigations of that kind. Indeed, the new accelerator might well be needed for far less sensational studies, bearing, perhaps on the structure of atomic nuclei, radiation damage research, or almost anything.

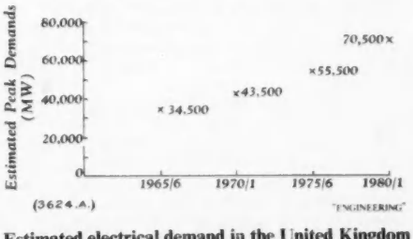
ECLIPSE OF THE FISSION REACTOR?

A further question relating to thermonuclear reactions concerns the purpose of the high-level conference which has been called to discuss the fusion process on June 4. Does this mean that the main problems of controlling the reaction have been solved? Has the stage been reached when firms must be warned (A.E.I., G.E.C., English Electric, British Thomson-Houston and Hawker-Siddeley are to be represented) to abandon orthodox fission reactor plans since the much more economical fusion process will soon be ready? Or is it simply the beginning of practical development in this field, so that the time has come to distribute research work? The conference may of course have the much more general task of deciding what approach to the problem should be adopted: pulsed electric discharges, small explosions or high-powered particle beams.

Other problems which call for speculation are the future demand for electrical power in this country; the basis on which the published estimates have been made; and how economically nuclear power stations are likely to contribute towards the anticipated requirement. The figures for electrical demand shown in the accompanying graph were estimated in September, 1955, and in December of that year Dr. G. H. Daniel of the Ministry of Fuel and Power, speaking before the Institution of Production Engineers, said that the fuel demand increased by 0·6 to 0·7 per cent. for every 1 per cent. increase in national output.

FORECASTING ELECTRICAL DEMAND

Since these two sets of information are to some extent related, we have an equation including only one unknown, national output. The question is whether this quantity represents the dependent or independent variable. In any case, can national output be anticipated over a period of 10 or 20 years? Or do technical innovations and economic fluctuations cause such discontinuities in the curve that prognostication is meaningless? If that is so, then power needs must also be incalculable. Estimates of future electrical consumption in Great Britain—as given, for instance, in the White Paper *A Programme of Nuclear Power*—appear to have been reached solely by extrapolating recent trends in demand, and, as far as is known, they have not been related to the wider problems of industrial and population growth. Moreover, the White Paper provides only brief details of the assumptions and arguments used in preparing the estimates.



Estimated electrical demand in the United Kingdom for period 1965 to 1980, calculated in September 1955. These figures have been obtained by extrapolating current demand; how reliable are estimates computed in this way?

Nobody doubts that power requirements will increase, but without knowing the method of analysis, industry cannot safely act on the conclusions.

New information on nuclear power costs is also due. In the White Paper (ENGINEERING, vol. 179, page 240, 1955), it was suggested that the cost of electricity produced from the first commercial atomic station would be about 0·6*d.* per kilowatt-hour, so that nuclear stations would be competitive with coal-fired stations. However, within recent months both Lord Citrine and Sir Christopher Hinton have stated that the early nuclear power stations would produce electricity at a gross cost higher than the current cost of power from base-load stations. What can have caused this revision in the estimate? The figures take into consideration the sale value of plutonium, which may have fallen in price owing to recent international events, though it seems possible too that rises in relative capital cost during construction of Calder Hall have changed the position. But since the capital costs for new coal and nuclear stations are likely to increase in step, the revised, less favourable, figures must represent a comparison between projected nuclear power stations and coal-fired stations already completed. In view of the continuous inflation of building costs this would hardly be a fair comparison. It would be much more equitable in these circumstances to calculate depreciation charges on replacement cost rather than historic cost. It is interesting to note that the Russians estimate the capital cost of nuclear stations to be 1½ times that of coal-fired stations, whereas in this country it is given as about double.

DEEP-SEA FREIGHTERS

The future of the nuclear reactor as a means of propulsion is also worth considering. Its place in the air remains very doubtful owing to problems associated with the heavy shielding necessary and crash dangers; combustible fuels still constitute the most convenient mobile source of power, though it is impossible to say as yet whether the hydrogen fusion process may meet aircraft requirements. However, at sea the picture is quite different. Mr. G. B. R. Feilden, engineering director of Ruston and Hornsby Limited, has stated that the closed-cycle helium gas turbine receiving hot gas directly from a nuclear reactor is quite a practical proposition; the standard Ruston TA gas turbine would be entirely suitable, though the compression ratio would fall from 4 : 1 to 2 : 1. It has also been suggested that future tankers and other merchantmen might be undersea craft powered by reactors; such vessels would avoid the resistance and other undesirable consequences of surface waves. Kipling's "deep-sea freighters" envisaged in his science fiction story "With the Night Mail" might yet become reality.

But however skilfully we speculate, even with the genius of a Kipling, a Jules Verne or a Wells, we cannot base industrial planning on our conclusions. A safe forecast can only be made on the basis of all available facts. That is the danger which follows from excessive security. No one can blame the Atomic Energy Authority; their orders come from a higher place, and scientists when free to be forthcoming are notoriously generous with their knowledge.

The habit of secrecy has a long history and perhaps the fact that Britain is now in the forefront of nuclear development is ample justification. This country has to compete commercially with other countries overseas with abundantly greater resources, and she is necessarily reticent of her discoveries, particularly since in the past she has sometimes been deprived of her fair share of information. But since the atomic conference in Geneva last year, the situation has changed. Research carried out in isolation by different groups is found to proceed at a common rate; if duplication were avoided and information exchanged it might advance more rapidly.

SECURITY AND PLANNING

Nowadays firms can obtain information from the Atomic Energy Research Establishment, but presumably only if they know the questions they want to ask. This is sufficient for development but not for long-range planning; for this a wide background knowledge is necessary, including data on current experiments. At present, with the exception of certain industrial groups which may be privy to the councils of the U.K.A.E.A., if a company wishes to plan for 10 to 12 years ahead it has to kidnap a Harwell specialist and make him a director, but in any case he is then cut off from the source. This is an unhappy state of affairs, since few industries are not in some way concerned with atomic energy.

Indeed, if the speculations made in this article are wide of the mark then their error lends force to its argument.

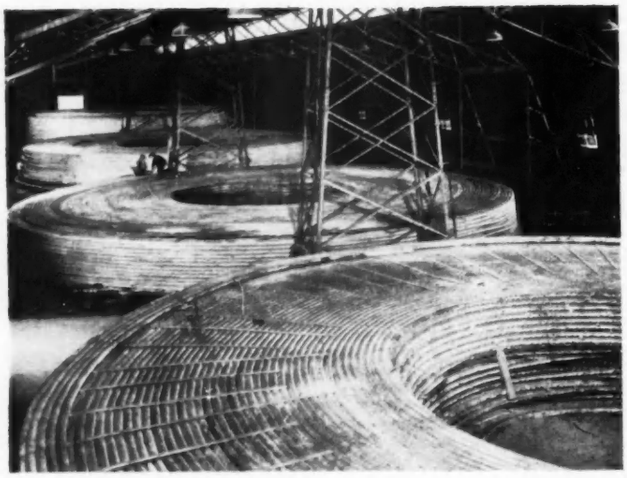


Fig. 1 View in the coiling down shed at Trafford Park showing the 138 kV submarine power cable.

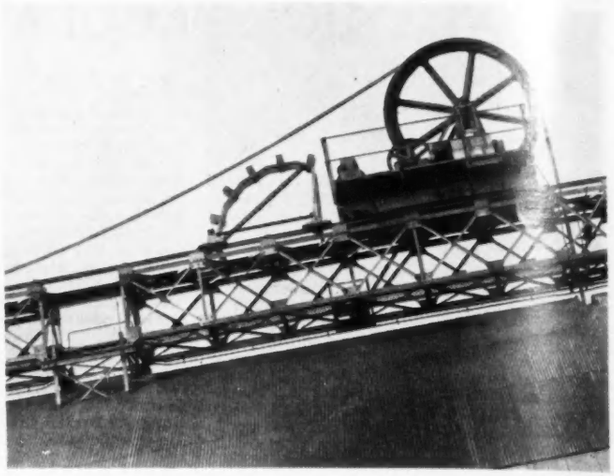


Fig. 2 Part of the gantry system showing the cable passing over a sheave-winch into one of the bays in the coiling down shed.

138 KV SUBMARINE POWER CABLE

A BRITISH-CANADIAN ELECTRICAL ENTERPRISE

An interesting stage has been reached in the enterprise of linking the high voltage system of the British Columbia Electric Company in the southern part of Vancouver Island with the water power resources on the mainland. To do this it was decided to lay a continuous length of 138 kV submarine cable from a point south of Greater Vancouver, and close to the mouth of the Fraser River, under Georgia Strait to an intermediate island and thence under Trincomali Channel to Saltspring Island on Vancouver. In all nine single core cables, each about 16 miles long, will be laid on the principal section and these in some places will be submerged more than 600 ft. below sea level. Similar cables, each about 3½ miles long, will be provided for the inter-island section.

The contract for the supply and installation of these cables was placed with British Insulated Callender's Cables, Limited, 21, Bloomsbury-street, London, W.C.1, and manufacture has now been completed, well ahead of schedule, at the Trafford Park works of British Insulated Callender's (Submarine Cables), Limited. Each cable is of the gas-filled type, the operating pressure being 300 lb. per sq. in. The cross section of the conductor is 0·35 sq. in. enabling some 120 MW to be transmitted over the system. The overall diameter is 4 in. and the weight about 50 lb. per yard. Generally speaking the cables are of normal design, but an outstanding feature is the long lengths in which they have been manufactured, thus avoiding the need for underwater joints throughout the route.

As cables many miles in length and weighing hundreds of tons cannot be wound on drums a power-operated gantry system was constructed from the factory to the dockside for loading it on to the ship for transport to Vancouver. This gantry crosses the Trafford Park Road at a height of 45 ft. and runs for a total length of 1,100 ft. to a tower, which has been erected 120 ft. from the edge of the quay. From this point two swivel beams, which can be swung through a small axis on rails mounted on a cross gantry, extend over the holds of the ship and thus provide twin cable runs.

STORAGE ARRANGEMENTS

To store the cable between manufacture and loading a steel-cladded shed 350 ft. long, 74 ft. wide and 43 ft. 6 in. high to the apex was constructed beneath a section of the gantry. A view inside this shed is given in Fig. 1 and, as will be appreciated, it provided an unobstructed floor area of about 20,000 sq. ft., so that five cable stacks, each with a diameter of up to 60 ft. could be stored.

Fig. 2 shows part of the gantry system which was erected over the coiling down shed and could be moved into position over any of the five coiling bays so that the cable could be laid where required. Withdrawal from the shed on to the ship is effected by a caterpillar erected on the gantry, which will pull a cable from its coil over the quadrant, visible in Fig. 2, to the winch and thence along one of the swivel beams, so that it can be lowered and coiled into the hold directly below.

TRANSPORT BY CABLE SHIP

To transport cables of this size to the site it is obvious that the most suitable method is to employ a specially equipped ship. The second largest cable ship in the world, the 4,600 ton "Ocean Layer," belonging to Submarine Cables, Limited, has therefore been chartered for this purpose and is being loaded at Trafford Park.

The Ocean Layer has recently been converted to a cable laying ship and is the first British vessel to be equipped with a Pleuger active rudder. This consists of an auxiliary propeller, additional to the main single screw, which is housed in the pear-shaped rudder blade and is designed to increase the manoeuvrability, which is so essential for cable laying. Her service speed is 11 knots and she is fully equipped with modern cable handling gear and testing apparatus as well as with electronic control devices and navigational aids.

When loading has been completed the Ocean Layer will sail for Vancouver via the Panama Canal, a voyage of 8,700 miles, taking about 40 days. At the conclusion of the voyage laying will begin in the Georgia Strait.

It may be added that this British Columbia project represents the culmination of two years development work and will enable a larger amount of electric power to be transmitted underwater for a longer distance at a higher voltage than in any similar installation.

MONOBLOC DIESEL COMPRESSOR

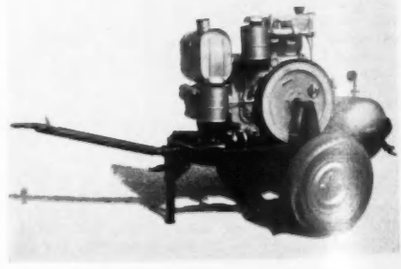
Available through the sole agency of Chamberlain Industries Limited, Staffa-road, Leyton, London, E.10, is the Jenbach single-stage Diesel compressor shown in the accompanying illustration. It is a development of the JW 15 K and will be known as the JW 20 K. A horizontal single-cylinder four-stroke Diesel engine is mounted as a single unit with a vertical compressor cylinder in one large engine block. By means of a secondary connecting rod the compressor piston is attached to the main connecting rod in a 90 deg. V arrangement, which relieves the crankshaft of a great part of the engine torque, and results in very smooth running. An adjustable speed governor has three settings of 1,000, 1,200 and 1,500 r.p.m. to give a choice of speed according to the air delivery required. An adjustable automatic cut-out governor maintains the pressure of the compressed air at the required value by controlling a check valve within the inlet port of the compressor.

Fuel is fed to the injection pump through a felt-disc filter. A single hole injection nozzle is used, spraying the fuel into a pear-shaped precombustion chamber. The governor, injection pump, and timing gear are grouped in small subassemblies which can be easily replaced and are accessible through detachable covers in the engine casing. A single cam drives both valves and the injection pump; the camshaft is thus kept very short. Forced lubrication is used.

The compressor cylinder has a bore of 135 mm. and a swept volume of 2 litres; at the rated continuous speed of 1,500 r.p.m. this gives a volumetric capacity of 106 cub. ft. per minute. Adjustable standard delivery pressures are 85 or 100 lb. per sq. in.

A new concentric valve is fitted to the cast-iron compressor cylinder head, in which a ring-shaped pressure valve surrounds a central suction valve; by this arrangement the pressure valve is cooled not only by the water jacket but also by the indrawn air.

As shown by the illustration, the unit is mounted on a two-sheel trailer and can be fitted with a weatherproof sheet-metal cover.



The engine and compressor cylinders are mounted at right angles on a single block and use a common crankshaft.

In Parliament

ENGINEERING DILUTEES

Ministers continue to be pressed for information respecting the status of engineering dilutees. At a recent sitting of the House of Commons, Captain H. B. Kerby (Conservative) asked the Secretary of State for Air what the minimum experience was which his Department and the Amalgamated Engineering Union had set up in 1939 as being sufficient to entitle a skilled employee in the Air Ministry to be recognised as a skilled craftsman. Mr. Nigel Birch replied that the Ministry regarded as fully skilled engineering craftsmen those who had served an engineering apprenticeship or who had obtained equivalent engineering experience. He could not, he said, answer for the union.

The Minister was also asked if he was aware that certain employees of the Air Ministry, who had entered the Department's service with no other industrial background than a Government vocational training course in 1939, were recognised as skilled craftsmen, while other persons, who entered the Ministry in similar circumstances a few months later, were permanently prevented from obtaining skilled status by the Ministry's interpretation of the Temporary Relaxation of Customs Agreement, 1939. Mr. Birch said he was not aware of this and that, therefore, the question of his taking steps to correct this " injustice " did not arise.

Dr. D. Johnson (Conservative) inquired how many dilutee craftsmen engaged on metal work became employed on skilled work at the Air Ministry during July, 1939, and how many such craftsmen were employed on skilled work at the Ministry during each of the first two quarters of 1939. Mr. Birch expressed his regret that these particulars were not available.

In another answer to Captain Kerby, the Minister said that he did not propose to compensate employees in his Department " whose conditions of service and prospects of promotion " had been " prejudiced by his interpretations of the Agreement." Administrative machinery for the interpretation of the spirit and intentions of the contracting parties in that Agreement, between the Ministry and the Amalgamated Engineering Union, was provided for in paragraph 5 (*a*) of that document.

ALLOWANCE FOR FUEL-SAVING PLANT

Colonel C. G. Lancaster (Conservative) asked the Chancellor of the Exchequer for particulars of the fuel-saving plant which he proposed should qualify for the investment allowance. In a written reply, Mr. Harold Macmillan gave extensive details, under six main headings, of the plant which he had in mind to prescribe for obtaining this allowance when the Finance Bill became law.

Some indication of the wide range of apparatus which it is intended should qualify may be gained from the following particulars. Under the heading of mechanical-firing equipment for solid fuel, Mr. Macmillan included, among other equipment, underfeed, chain-grate and ram type mechanical stokers; pulverised-fuel burners; and solid-fuel elevators, conveyors and hoppers, installed as a necessary part of a mechanical stoker or pulverised fuel burning installation. Under the heading of oil-firing equipment, he included fully automatic, semi-automatic and hand controlled oil burners of various types; and such items as oil storage tanks, tank gauges, oil filters, oil pumps and service piping, installed as a necessary part of an oil-burning installation. Another heading covered engines and turbines which discharge the whole of their exhaust vapour to process steam or heating systems, as well as electrical alternators and generators, switchgear, steam driers, superheaters, and similar apparatus installed as a necessary part of a high-pressure installation. Under waste-heat recovery equipment, he included flue-gas feed water economisers, waste-heat boilers, air pre-heaters which recover heat from hot waste gases for heating air for combustion purposes, and certain types of heat exchangers and recuperators. The remaining main headings were feed-water treatment plant in a steam boiler installation, and control equipment.

WOMEN INDUSTRIAL CIVIL SERVANTS

The Chancellor of the Exchequer was asked by Dame Irene Ward (Conservative) for the number of women in the industrial grades of Government employment, and in each of the main branches of work undertaken by them. Mr. Henry Brooke, Financial Secretary to the Treasury, said that there were 50,387 women employed in the industrial grades by Government Departments on April 1, 1956, of whom 8,087 were part-time employees. No precise analysis of this total figure was kept centrally, but an approximate estimate, based on figures specially compiled in November, 1954, showed that some 13,000 of these women were employed in the engineering and shipbuilding industries, and that another 6,000 were engaged in chemical manufacture. Agriculture accounted for 1,000 women, printing and bookbinding for 900, and clothing for 600. Some 10,500 industrial women employees were engaged in catering, domestic work, cleaning and portering; 2,500 were employed on stores and packing; and the remainder, numbering some 16,000, worked as motor drivers, messengers, gardeners and in labouring capacities.

Scientific Films

In his capacity of representative in the House of Commons of the Lord President of the Council, Mr. J. R. Bevins, the Parliamentary Secretary to the Ministry of Works, was asked about the work of the Scientific Film Institute. He told Mr. E. G. M. Fletcher (Labour), who raised the matter, that a sum of £48,750 was included in the current year's estimates as a grant to the British Film Institute. The Minister added that he understood that the Institute proposed to allocate £2,850 of that amount as a grant to the Scientific Film Association.

During the financial year ended March 31, 1956, the British Film Institute received a grant-in-aid of £50,400 from the Treasury and it was understood that, during that period, the Institute allocated £2,800 to the Scientific Film Association. At the present time the Association had about a hundred corporate members and about 200 individual members. The annual subscriptions of these members totalled about £720.

Technical Assistance for West Africa

Mr. James Johnson (Labour) desired to know whether the Secretary of State for the Colonies was aware of the desire in West Africa, and particularly in western Nigeria, for a Colombo Plan to extend technical aid to that region, and whether the Minister would initiate discussions with the appropriate local Governments. In reply, Mr. Alan Lennox-Boyd said that there was undoubtedly a keen desire in West Africa for technical assistance and that constant attention was being paid to the matter to ensure that the arrangements for securing it were adequate.

Increased Grants for Welsh Roads

Replying to Mr. E. H. Garner-Evans (National Liberal and Conservative), who sought information regarding the amounts allocated recently for improvements to Welsh roads, Mr. Hugh Molson, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that £2,374,703 was being made available by his Ministry during the 1955-56 financial year for major improvements and new construction work on trunk roads in Wales and Monmouthshire, against £1,055,374 during the 1954-55 financial year. The sum being made available for maintenance and minor improvements to such roads would amount to £1,114,515 in 1955-56 compared with £1,062,000 in 1954-55. Grants to local authorities for major improvements and new construction work on classified roads in the area would amount to £595,966 for 1955-56, against £938,291 for 1954-55. Grants for maintenance and minor improvements to these classified roads would amount to £2,021,684 for 1955-56, against £1,867,795 previously.

London to Yorkshire Motorway

In a written answer, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, informed Sir Frank Markham (Conservative) that the construction of the proposed motorway from London to Yorkshire could not be authorised until he had sanctioned the scheme under the provisions of the Special Roads Act, 1949, and completed negotiations for entry on to the land required. The Minister said he had given instructions for these statutory processes to be pressed on, but they would still take a considerable time.

Road Approaches to London Airport

Mr. Watkinson told Mr. R. Gresham Cooke (Conservative) that the whole problem of providing adequate road approaches to London Airport, and of relieving congestion on the Bath Road in the vicinity of the Airport, was under urgent examination, but that he had not yet decided what improvements it would be possible to obtain. There were three possibilities. There was the question of a new railway into the Airport, the possibility of a mono-rail service between London and the Airport, and proposals for either improving the Bath Road or building a section of the new motor road which would link up with the Cromwell Road extension. He was not yet in a position to decide which of these was the best and which, therefore, should receive priority. He agreed that it was essential to secure better access to the Airport and that the Bath Road might require to be widened, but there might be a better alternative to that, and it was this problem which was now being studied.

Graduate Scientists in Government Service

In reply to Mr. Austen Albu (Labour), who inquired as to the number of graduate scientists employed by his Department, other than on civil-aviation and road-construction work, Mr. Watkinson said that no graduate scientist was employed in the scientific officer class in any section of his Ministry covered by the question. He agreed to look into a suggestion by Mr. Albu that the Ministry of Transport and Civil Aviation would be helped by operational research into transport problems and that scientific advice would be of great assistance in that connection.

Flashing Indicators for Motor Vehicles

In answer to questions by Sir Frank Medlicott (National Liberal and Conservative), Mr. R. F. Crouch (Conservative) and others, requesting a statement of policy regarding flashing indicators, Mr. Watkinson said that, after careful consideration of a report by the Road Research Laboratory, he had reached the conclusion that all three types of direction indicator now permitted should continue to be legal in this country, both to meet the needs of different classes of vehicles and as an aid to the export trade.

A statement issued by Mr. Watkinson subsequently referred to the requirements of the export trade and said that it would be uneconomic to adapt a car model so that it could be fitted with different types of indicator, one for the export trade and one for the home market, because the two systems would require different wiring and different openings in the bodywork. The fore-and-aft type of flashing indicator had been criticised on several grounds but much of this criticism had been directed against the indicators fitted to vehicles when this type was first legalised in 1954, and a code of practice had been issued to manufacturers, the adoption of which should remove many of the obvious defects. Certain alterations in the regulations were called for, however, and he was circulating to interested organisations, for their comments, proposals that on all vehicles registered for the first time on or after January 1, 1959, amber should be the only permitted colour for all types of direction indicator; fore-and-aft indicators should be required to be separated from other lights; and the maximum and minimum intensity of indicator lights should be prescribed.

THE HUMAN ELEMENT

Quality or group loyalty—Promotion by merit—Decrease in car sales a world problem—Wage earners are also consumers—Younger men and higher earnings—Higher wages may mean no jobs.

★ ★ ★

Building Professional Influence

In these days when political and economic influence is all too readily measured by counting the heads, it is of interest that professional men are becoming increasingly exercised about how to make their influence felt with such juggernauts as the nationalised industries and the State itself. There was a recent case of this awakening interest at the conference held by the Institution of Professional Civil Servants. One delegate pointed out that if the employers and the unions were able " to grind their own axes in Downing Street " it was high time the professions did the same.

Another example of the way the wind blows was the announcement last week by the British Transport Commission that it would negotiate wages and salary conditions only with organisations which it recognised for the purpose. This is one more step in the direction of the closed shop and gives added significance to those organisations like the Engineers' Guild which have been trying to find some middle way between the discipline of professional standards and the union card.

The basic danger in this trend is not only that quality of influence becomes swamped by numbers, but that the corporate State arrives almost unannounced. Everyone becomes judged in relation to some pressure group or other. To the professional man this must mean a decline in status, for he is bound to become a craftsman with loyalties to his job instead of to his clients. The sanctity of the individual, not technical expertise, lies behind the idea of professional conduct and that idea is now having to fight for survival.

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Looking for Managers

By a coincidence, two important pronouncements have been made in the last week on finding and training good managers. The first of these is a report by the Acton Society Trust called " Management Succession " which, briefly, shows how few companies as yet make any systematic attempt to find and train good men. The second is the annual address of Lord Heywood to the shareholders of Unilever Limited. This year, Lord Heywood dealt exclusively with the ways in which the Anglo-Dutch partnership (of which Unilever is the British side) tackles the problem.

It is worth remembering that Lord Heywood has given extensive consideration to this question and he was indeed one of the driving forces behind the establishment of the Administrative Staff College at Henley some ten years ago. Despite this interest in the college at Henley (which stands broadly for the cross-fertilisation of ideas among promising men destined for promotion to top management) his attitude, as shown in his speech, remains exceedingly pragmatic. The process by which a senior manager " arrives " at Unilever is essentially by rough surveillance through a system of checks and balances, by recommendation and vetting by committee, by delegated responsibility and a system of controls, by systematic training within the Group and possibly outside it (as at Henley for three months secondment) and also by being thrown into the pool of day-to-day experience and being watched as he swims out of it. The system itself is flexible and tries to keep on learning—a prescription which might also be applied to the men it trains. But it remains a system, carefully planned, and any inconsequence it may show is deliberately contrived. Unilever evidently takes its " manager problem " seriously.

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Four-Day Week by Rota

The management of the Standard Motor Company have been trying manfully to meet the wishes of their employees and to allay their fears. The 5,000 car workers at Canley are to work a four-day week on a rota basis to absorb 1,000 tractor workers, while new machinery is being installed at Banner Lane. Attempts are being made to absorb another 1,000, on the basis of a proposal by the union leaders for these men to stand off for one week in five on a rota at a guaranteed wage of £6 per week. Unemployment benefit will be claimed, and presumably paid, for idle days.

Now that negotiations are being conducted on a more reasonable basis of give-and-take there is hope that another stoppage will be averted. Yet it is hard to see how redundancy can be avoided altogether when car output continues to fall. In the United States more and more workers are being laid off and unless the trend is reversed fairly soon some companies may have difficulty in meeting their commitment for a guaranteed annual wage. The Third International Automotive Conference which ended in Paris last week showed that the problem is world wide, and exceedingly complex. The Conference, which represented 3 million workers employed in the motor vehicle and components industries, considered that the capital expansion of the industry had been on a " fantastic " scale and carried out in a most irresponsible manner. Governments must be made to face the responsibility for the social upheaval this is causing and take over the task of safeguarding " these individuals, companies and communities which would otherwise be affected by automation." It is difficult to reach a different conclusion.

★ ★ ★

Co-operatives on Wages

The emotional bond between many in the Co-operative Movement and the Labour Party never looks less logical than when the subject of wages is discussed. A wide chasm separates those idealists in the Co-operative Movement who put the consumer first in the matter of prices, and the trade unionists who are anxious to get the maximum cut possible for their members out of higher prices and profits. There is after all a big difference between a sacred cow and a milch-cow.

These differences came out last week at the annual Co-operative Congress at Blackpool when a plea was made for a national wages policy in the interests of the consumer. After all, said the speaker, we are all consumers—a profound truth which carries remarkably little weight on either side of the negotiating table. The speaker went so far as to say that he had noted with foreboding an announcement from Germany that certain unions were to press for automation so that they could get a bigger share in the profits. The speaker obviously would have preferred the lion's share to go in lower prices. He is likely to get as sympathetic a hearing in certain quarters as Galileo did when he declared the world to be round. Any plea for a national wages policy, which must mean some form of pegged wages, will receive scant attention from the unions.

To many, both in the unions and outside them, the Co-operative Movement stands for low wages and salaries, and they point to inefficiencies within the Movement as the consequence, particularly, of low salaries. That is the weakness of the Co-operative case. If ever the Movement could show that high wages and salaries could go with falling prices it would have a larger audience and membership.

★ ★ ★

Machine-Minded Dockers

Unofficial leadership of the London dockers has for once exercised restraint and deliberately averted a strike over the introduction of new mechanical-handling equipment. The Port of London Authority have opened, in the Royal group of docks, two new sheds specially designed to assist in speeding up loading and unloading, using fork-lift trucks which enable loading gangs to be reduced from eight men to three and unloading gangs from eight to six. A meeting was called to consider the situation. The unofficial leader, Mr. W. Jones (who achieved prominence in the 1954 dock strike) took only 5 minutes to assure the men there was no need to worry about the machines, that there was plenty of work for everyone and that he and his colleagues would watch the situation closely and would ensure that their Union (T. and G.W.) did likewise. He said " we do not want a major stoppage on our hands " and everyone went happily back to work.

Also last week the National Dock Labour Board published their annual report, which showed that the number of dock workers in Britain's main registers had risen by 3,300 to 77,743 over the past 12 months. Apart from growing bigger, the labour force is getting younger: the average age fell by about a year to 45½ and the proportion of men under 35 rose to 24 per cent., higher than ever recorded before. There has been a high and stable level of employment and gross average earnings rose from nearly £11 a week to £12 9s. 7d.

To achieve greater flexibility in the labour force, and to improve its quality, the Board have decided to encourage local labour Boards to establish " probationary registers " to train men who could help to overcome temporary shortages and could be used to fill vacancies on the main register when they occur. It is to be hoped that the Board will take advantage of favourable conditions to strike at the roots of the troubles that have plagued management-labour relations at the docks for so long.

★ ★ ★

The Chancellor and the Unions

Mr. Macmillan, Chancellor of the Exchequer, said last Friday in Newcastle-upon-Tyne, that further wage demands could wreck the National economy. His argument was simple enough: if wages rise and prices rise with them, no-one is better off but British exports cease to be competitive. The net result would be a fall in living standards, a fall which could develop into a disastrous collapse. His colleague Mr. McLeod, Minister of Labour, had said the day before at the opening of the Production Exhibition that the need to raise the productivity of British industry was urgent: " time is not on our side."

Union leaders generally recognise the wisdom of both these arguments. But the long tradition of " fighting for what you can get " is there to contend with. At their annual conference, the Amalgamated Society of Woodworkers rejected their leaders' advice not to press for an immediate wage increase and carried a resolution " to take the necessary militant action " to secure a claim for a 9*d.* an hour increase. Clothing workers are pressing for 4*d.* an hour, maintenance craftsmen in steel are dissatisfied with their recent advance of 10*s.* a week, fishermen are demanding a " substantial " increase, civil servants want 5 per cent. more, the Fire Brigades Union want a new wage structure and more pay. Union conferences have already agreed to press claims for a " substantial " increase (probably £1 a week) for engineering and shipbuilding workers, about 33*s.* a week for building workers and something indefinite for shop workers. Railwaymen and miners are agitating for the submission of claims. Engineering unions are pressing for equal pay for women.

Small wonder the Chancellor is worried: pay increases on a fast expanding output can often be absorbed without affecting the unit cost. On a falling output they can wreck having. Now more than at any time since the war both sides of industry take good care they do not manoeuvre themselves out of a job—either by failing to modernise or by asking for too much money. But where is the leader who can unravel this desperate tangle of human aspirations and fears?

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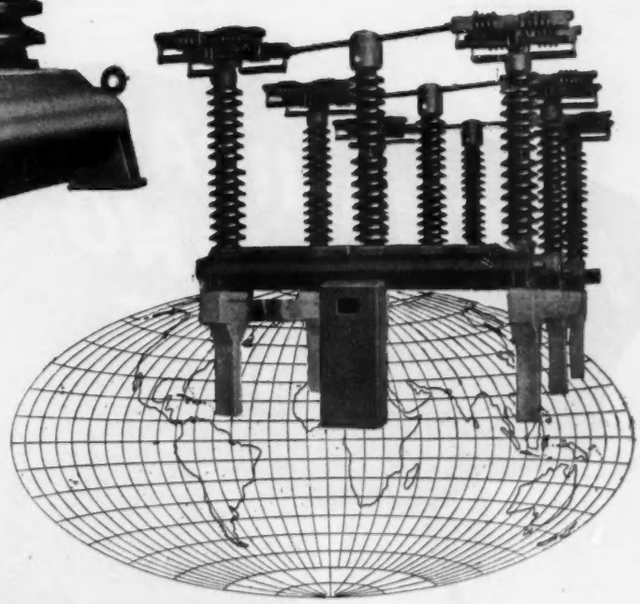

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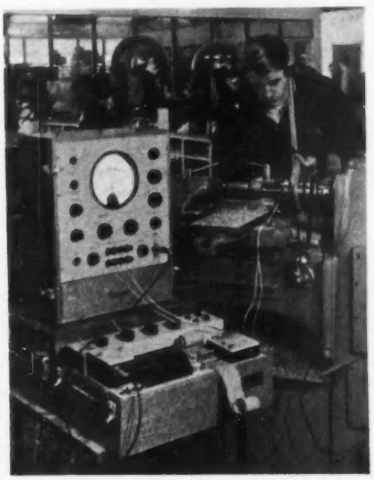

Application shows Strain Gauge Apparatus Type 1516 and Level Recorder Type 2304 used on a lathe for low cutting-speed measurements.

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With Accessories Type 1536 and 1537 measurements of strains at up to 50 positions can be taken.

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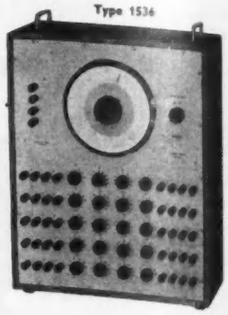

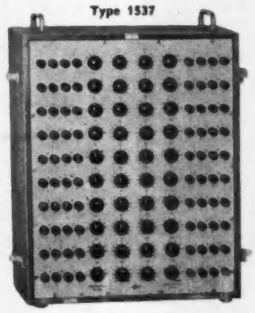

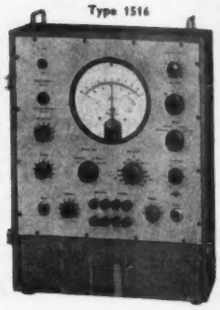

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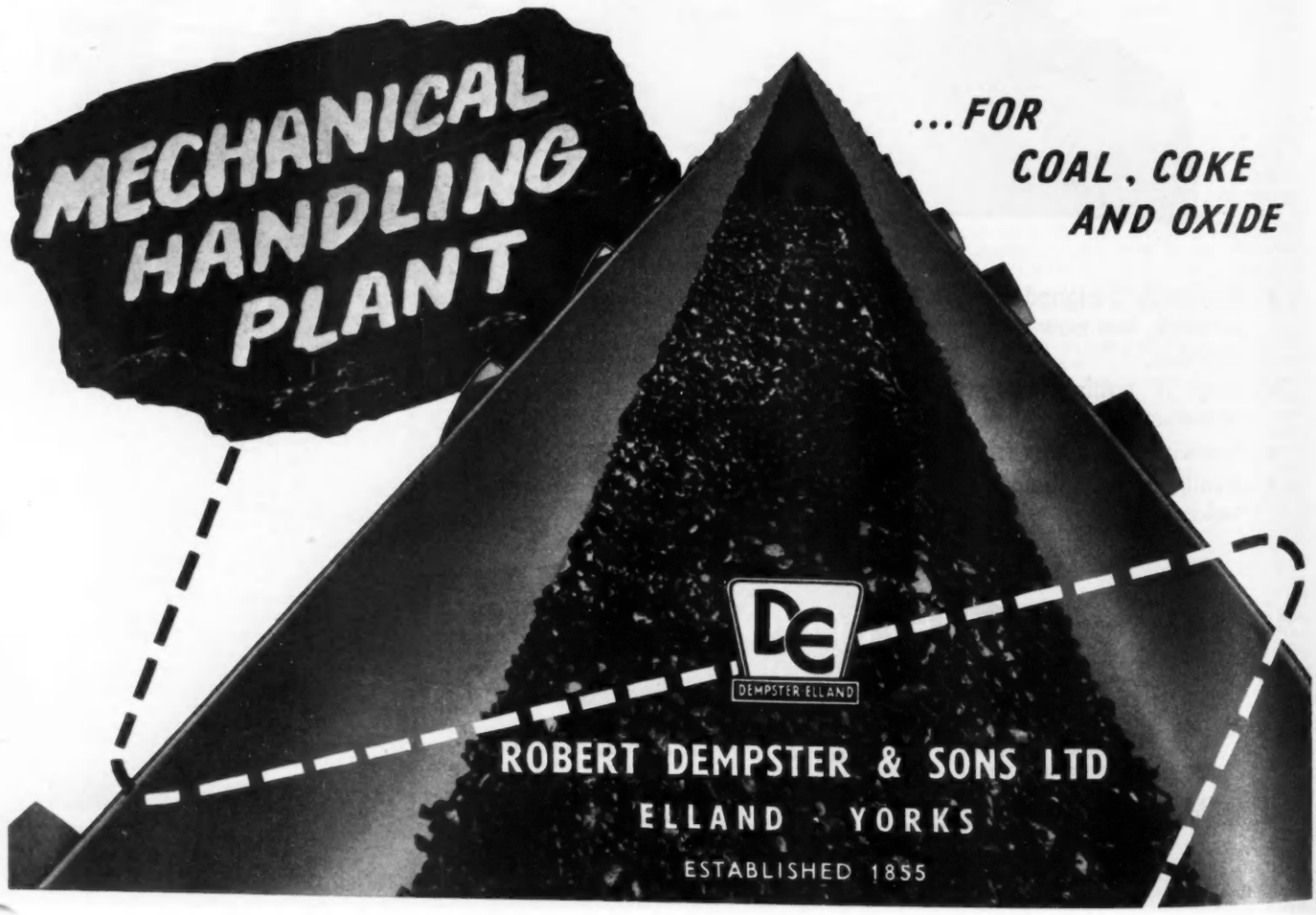
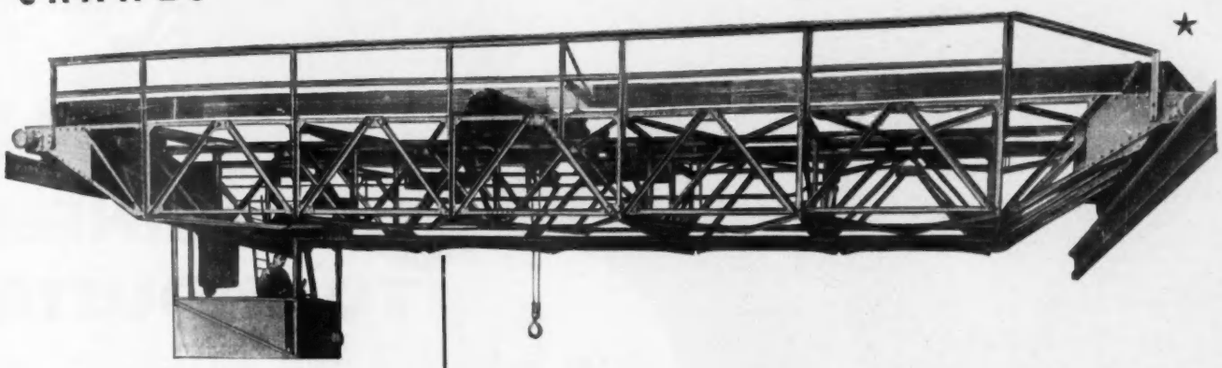


POWERED CRANES



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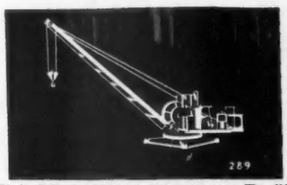

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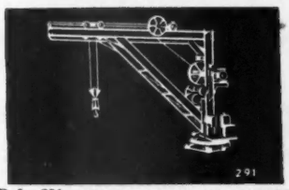

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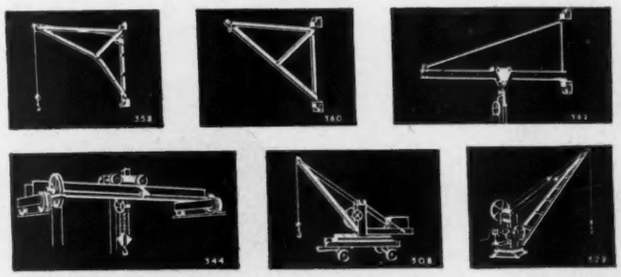

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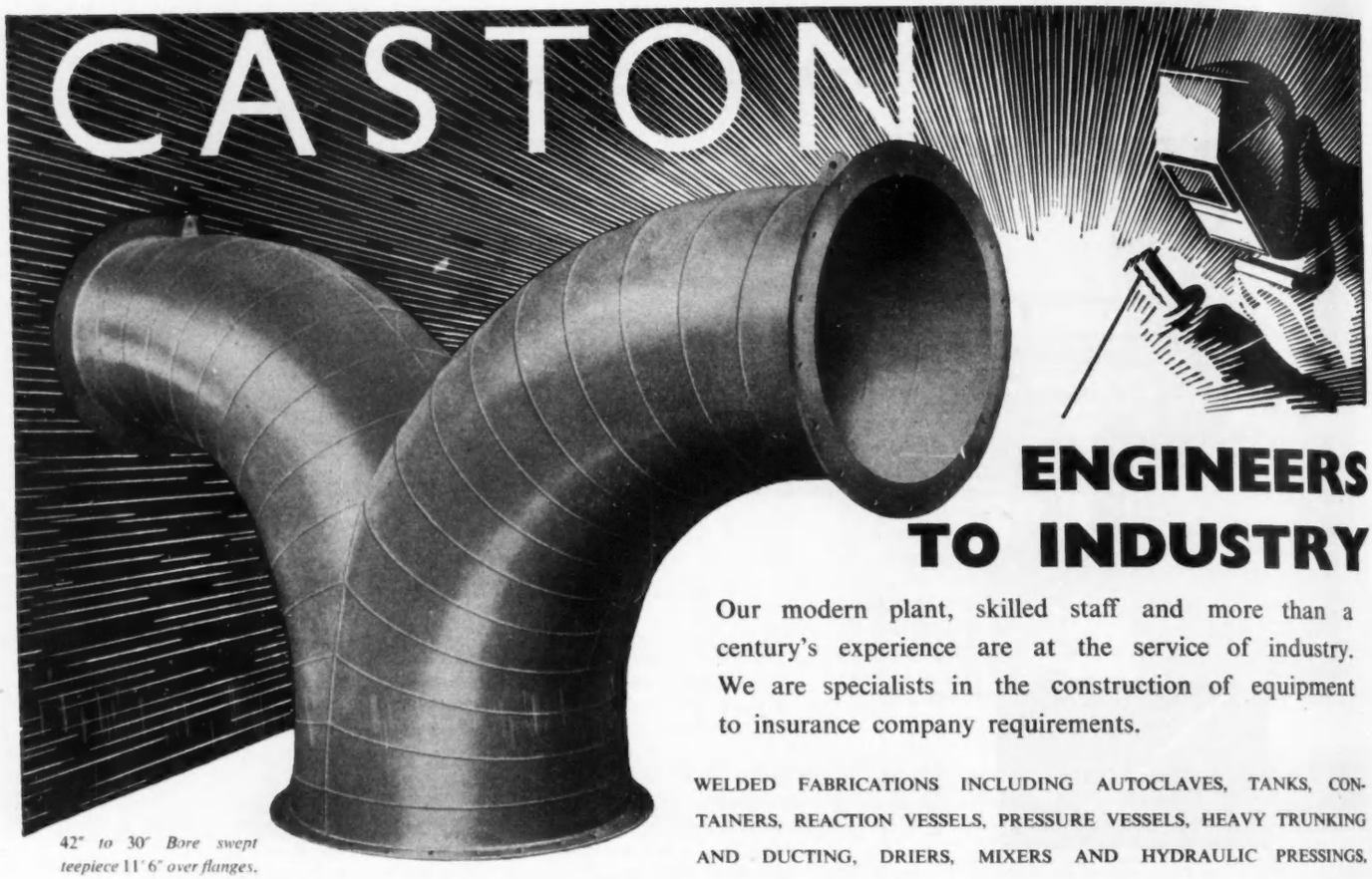

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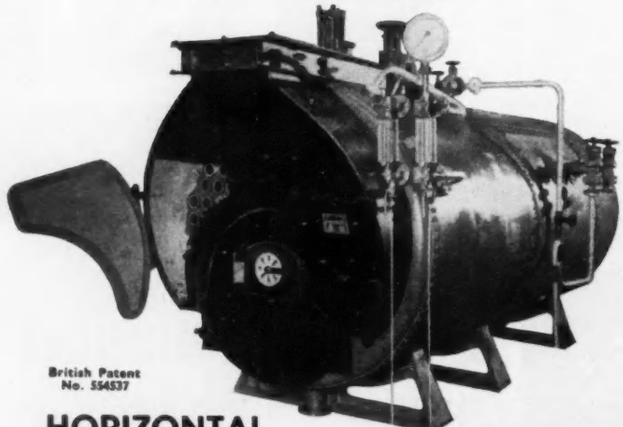

British Patent No. 554537

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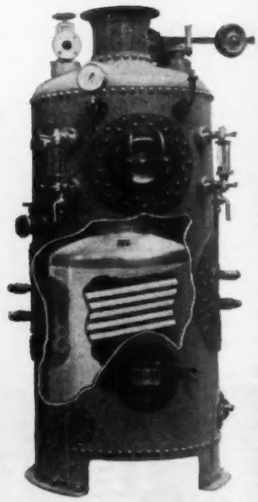

Evaporative Capacity from 850 lb. to 3500 lb. water per hour. British Patent No. 642266.

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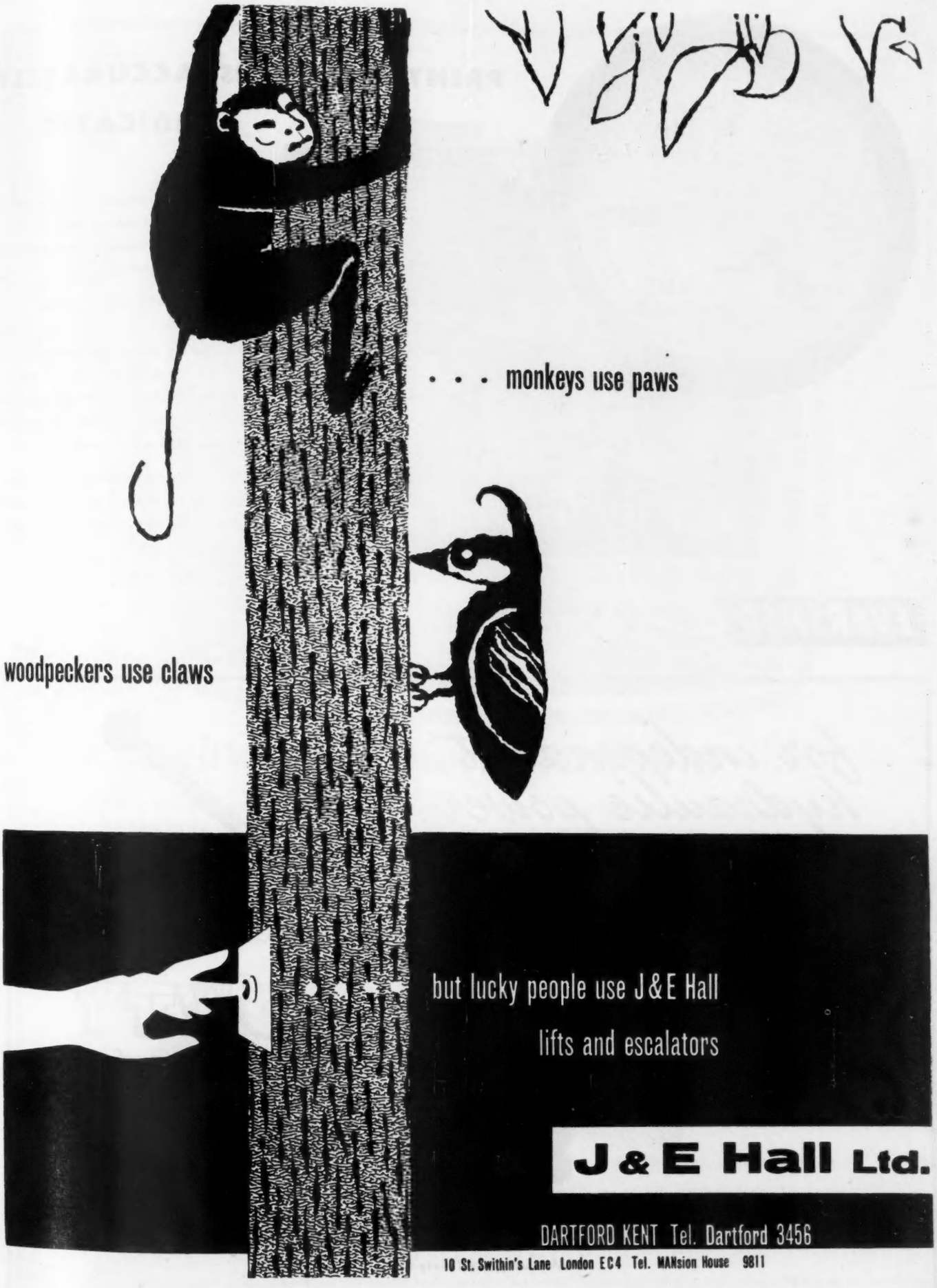

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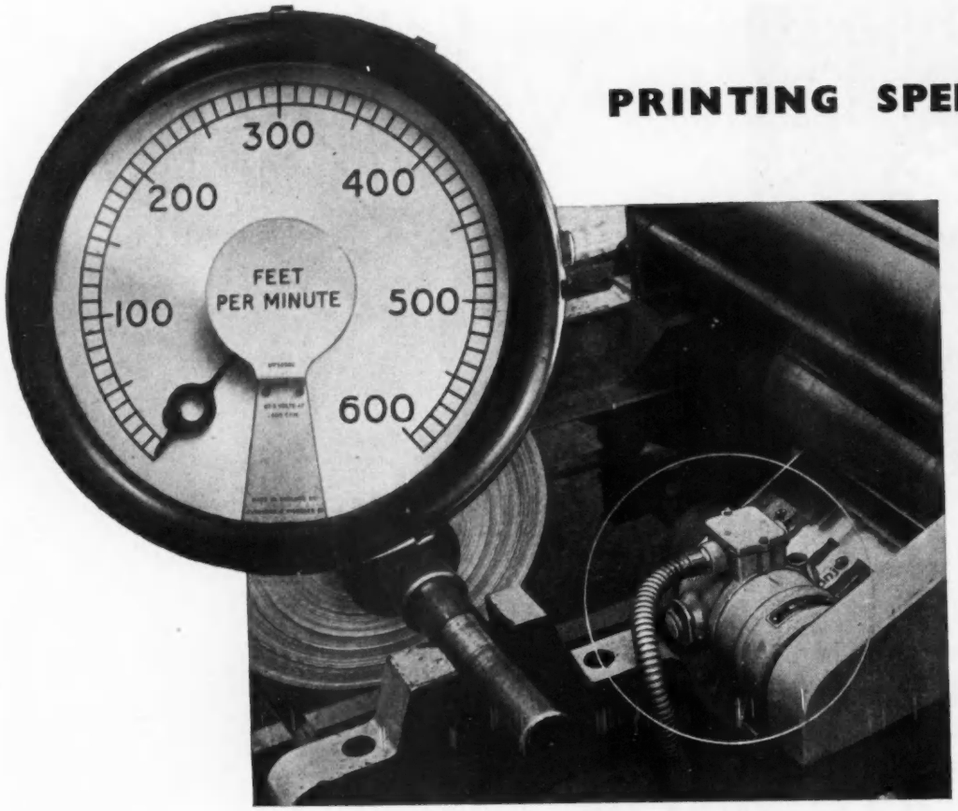

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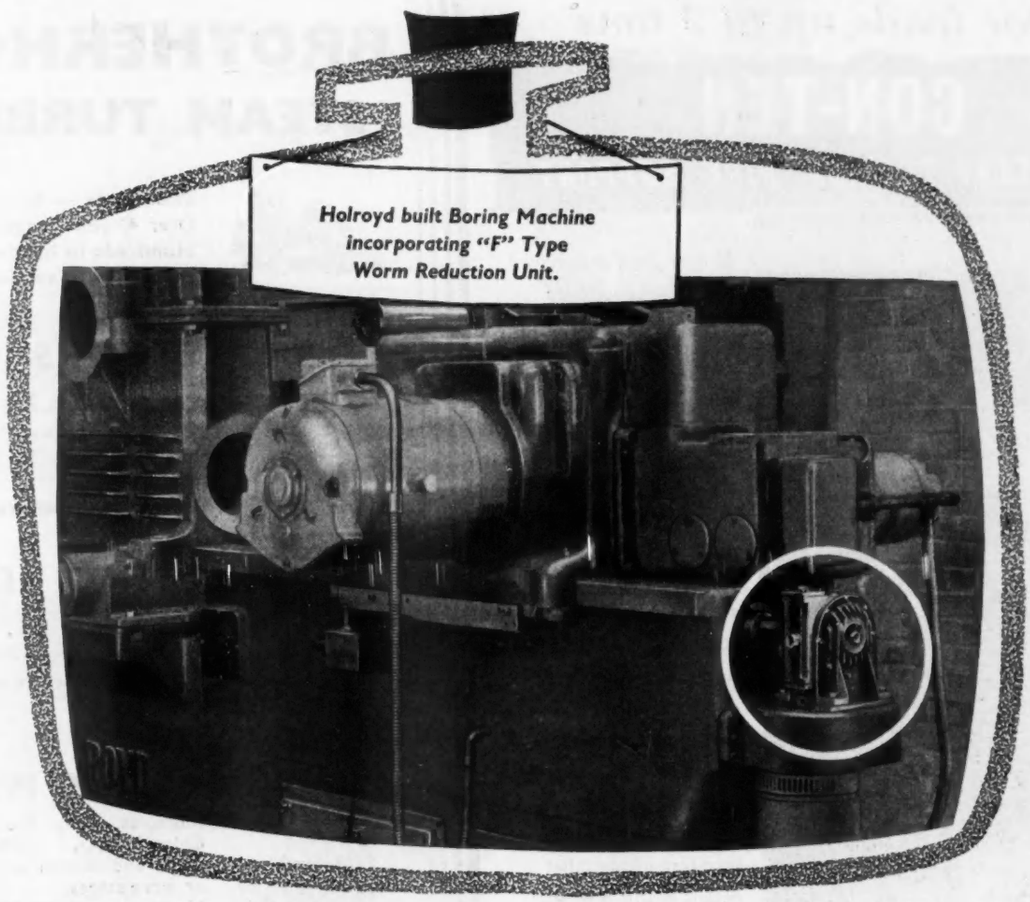

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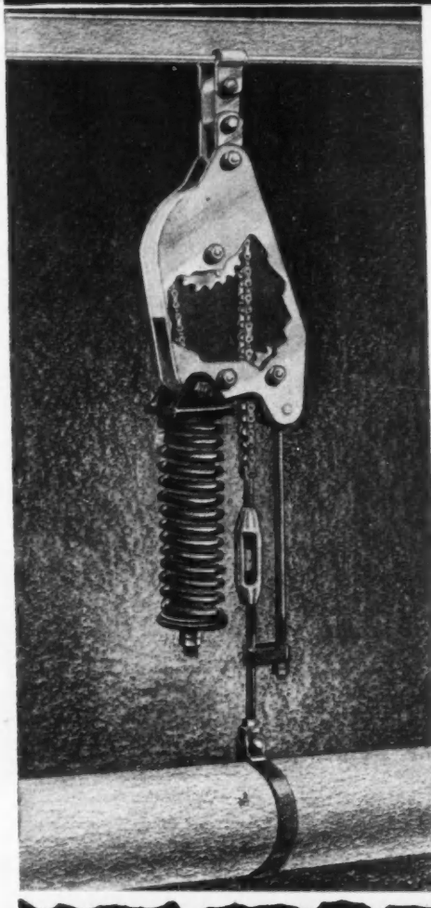

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British Patent No. 474008
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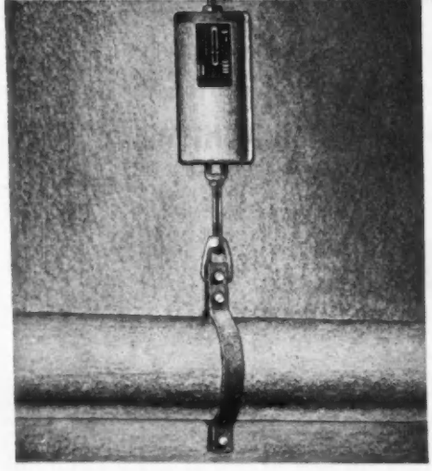

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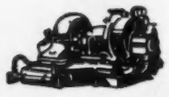

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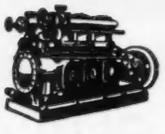

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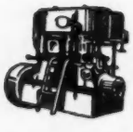

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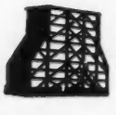

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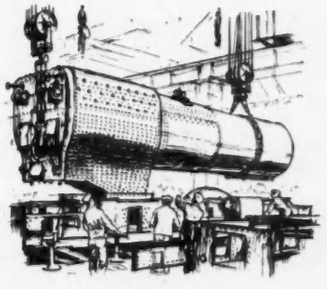

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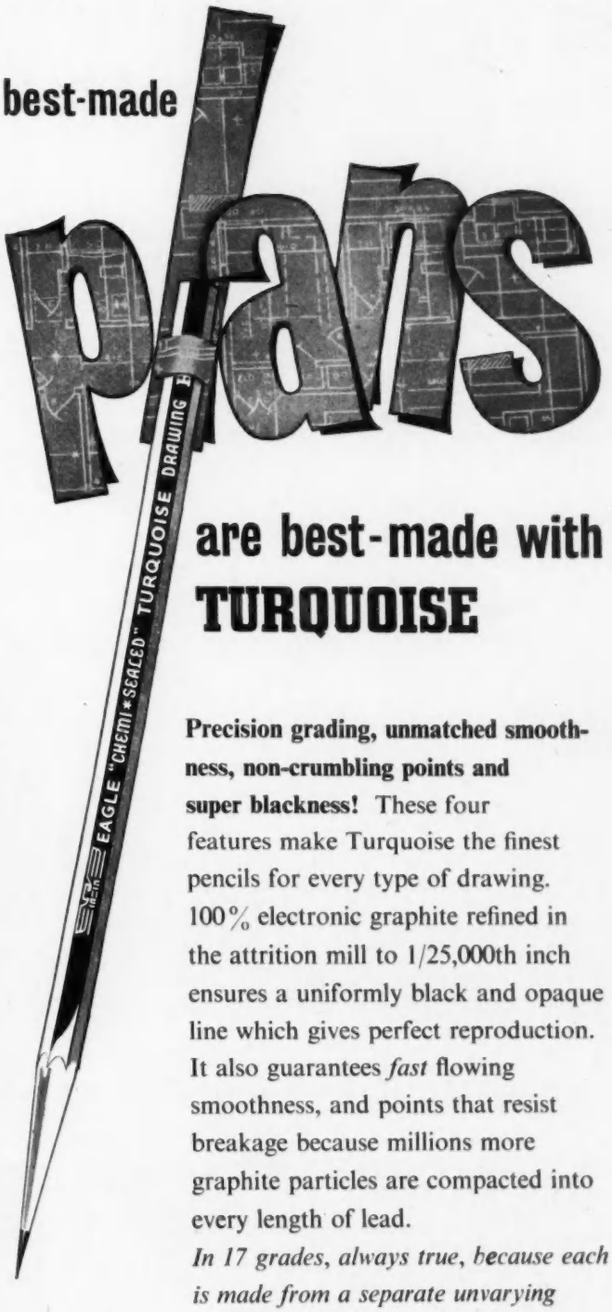

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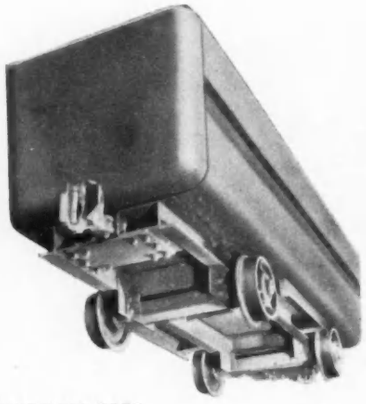
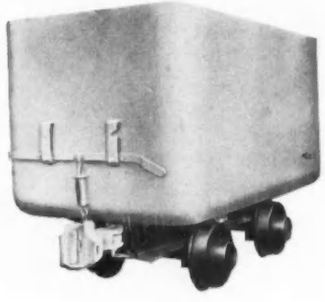
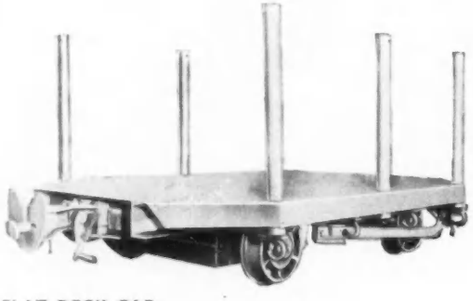


SOLID BOTTOM CARS





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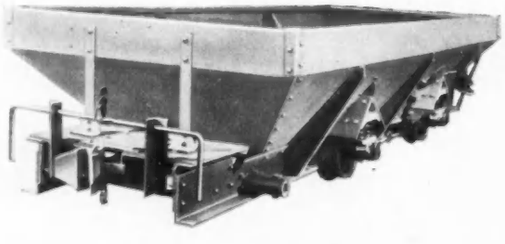
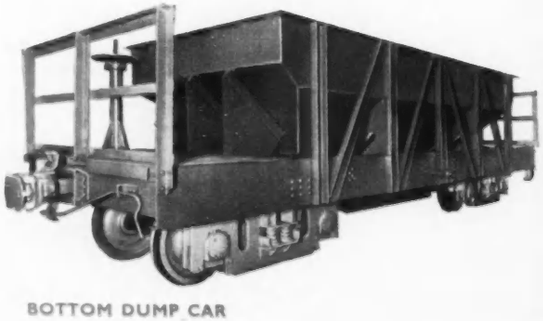
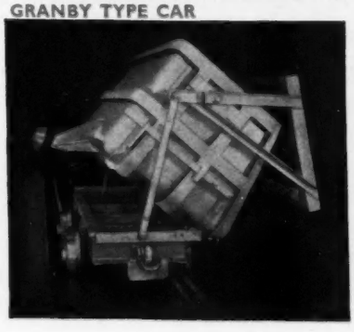


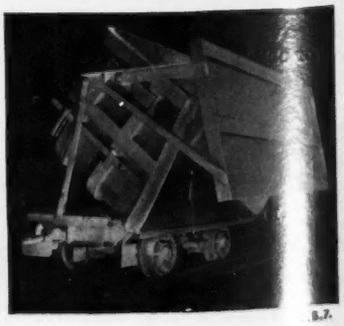
AUTOMATIC DROP-BOTTOM CAR



BOTTOM DUMP CAR

GRANBY TYPE CAR

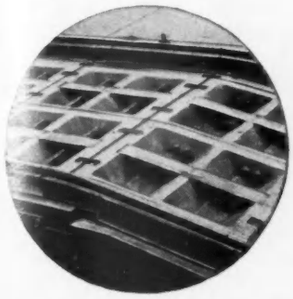




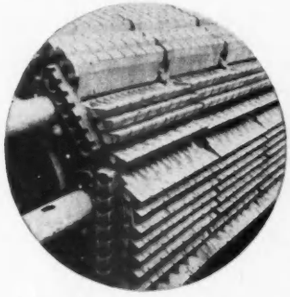
B.T.

Proved Performance with the

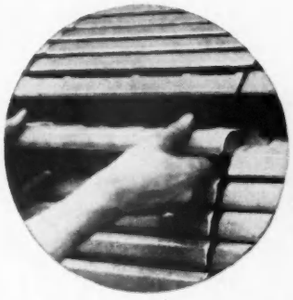
'L' Stoker



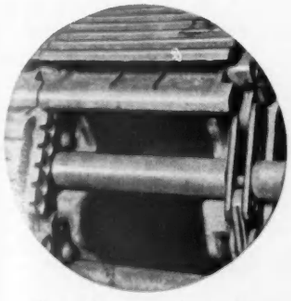
Close control of air supply gives even burning and allows fuels varying from refuse to anthracite to be used efficiently.



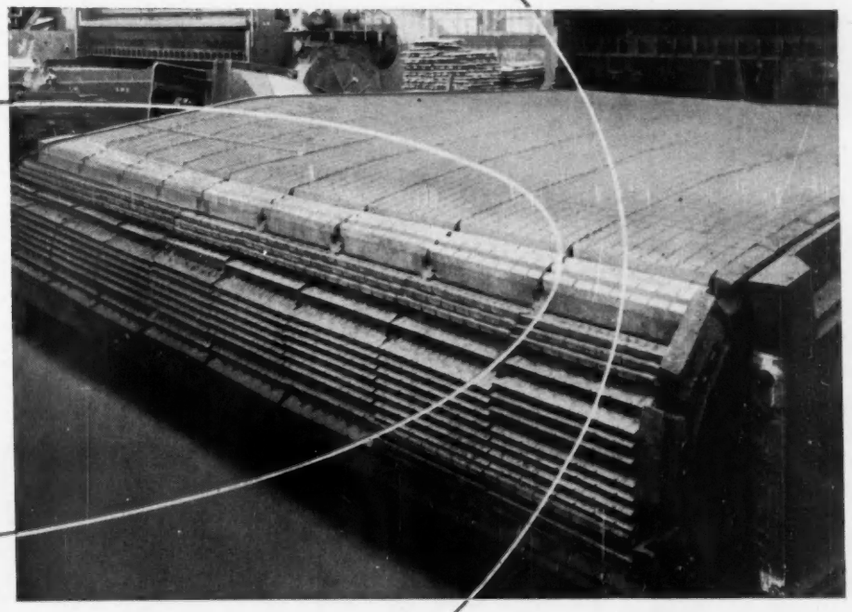
Automatic cleaning of fire bars, which are free to grow without affecting efficiency.



Parts requiring attention are easily accessible and renewable with minimum interference to stoker operation.



oker chains are distinct from te surface so that each is free perform its own function.



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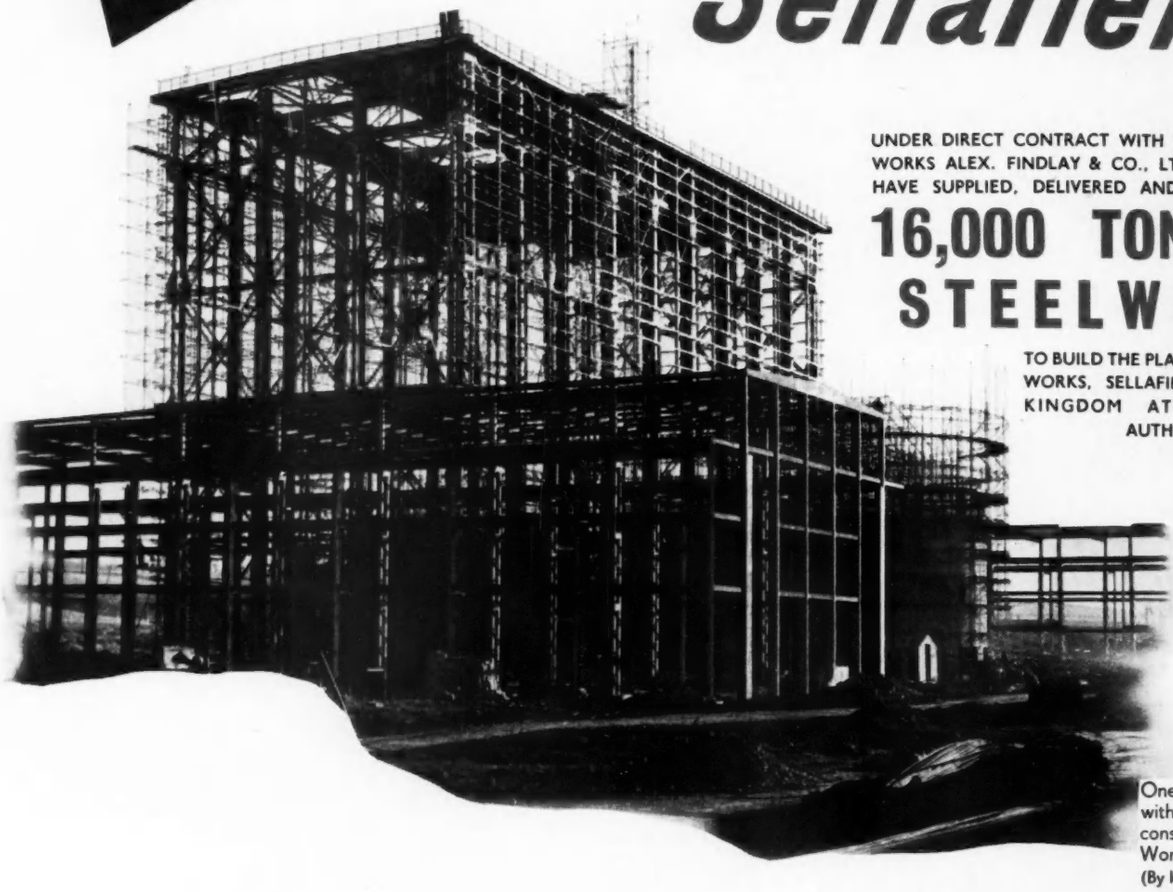

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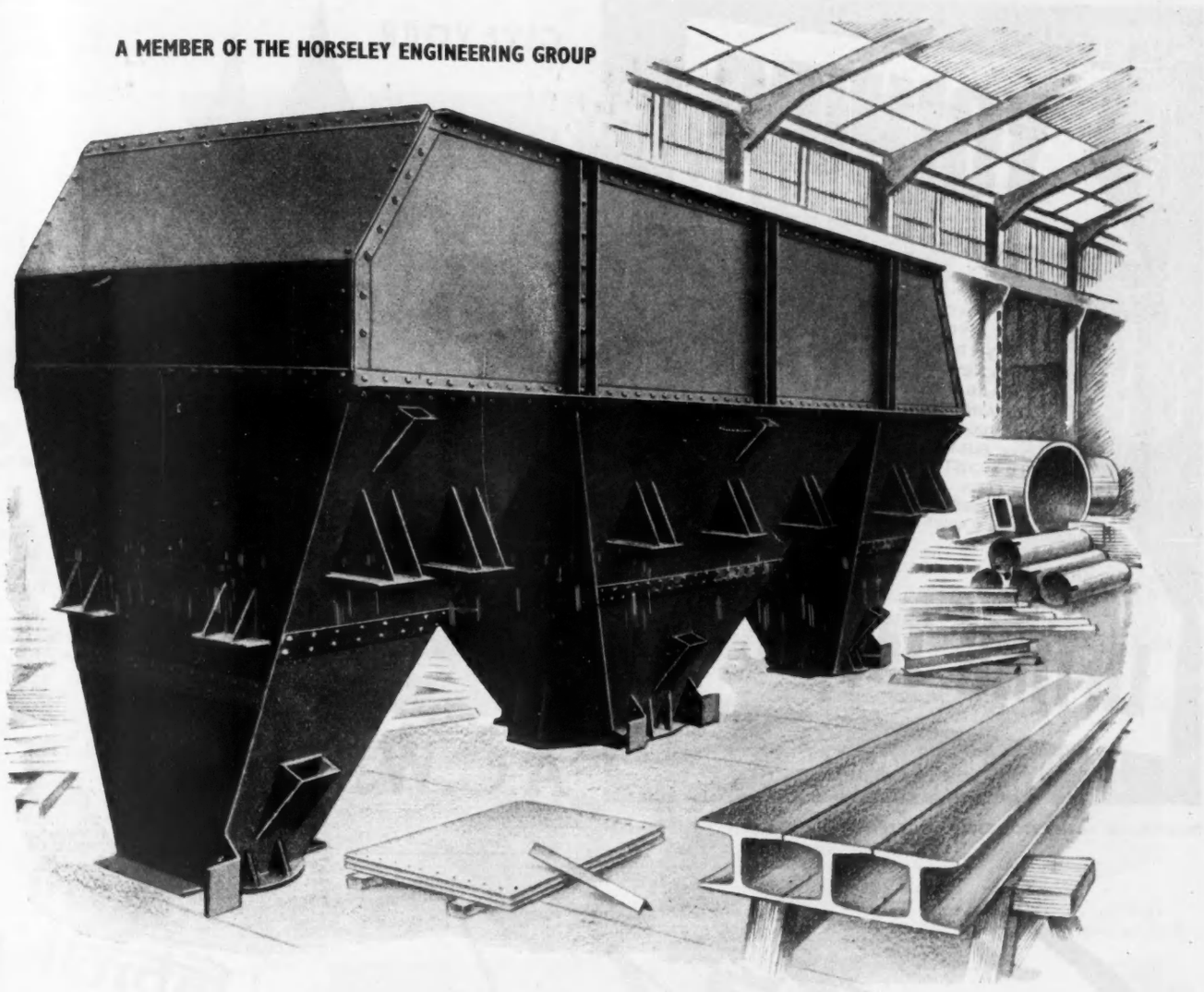

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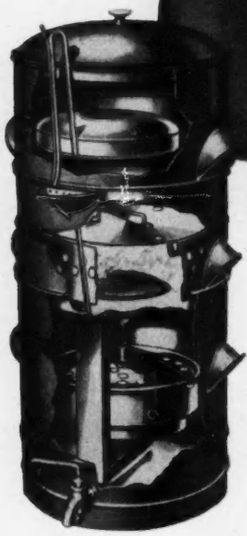

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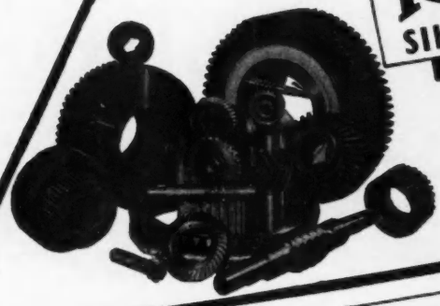

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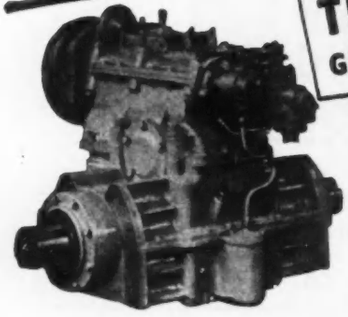

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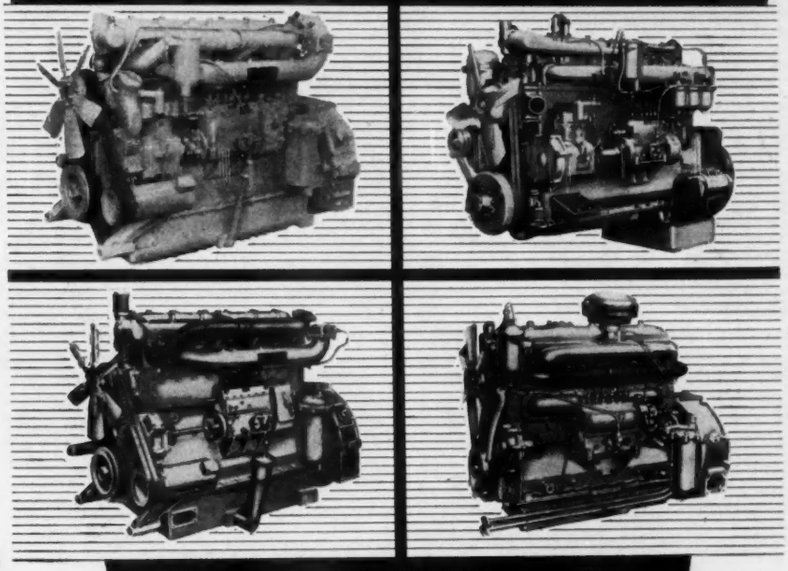

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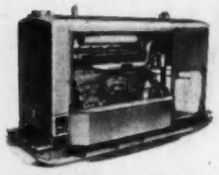

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680 Vertical or Horizontal	5 in. (127 mm.)	5.75 in. (146 mm.)	677 cu. in. (11.1 litres)	1,640 lb. (744.5 Kg.)	150 b.h.p. at 2,000 r.pm.	135 b.h.p. at 2,000 r.p.m.	115 b.h.p. at 1,800 r.p.m.
900 Vertical or Horizontal	5.5 in. (139.7 mm.	6.5 (165.1 mm.)	927 cu. in. (15.2 litres)	2,580 lb. (1170.2 Kg.)	200 b.h.p. at 1,840 r.p.m.	170 b.h.p. at 1,800 r.p.m.	142 b.h.p. at 1,600 r.p.m.

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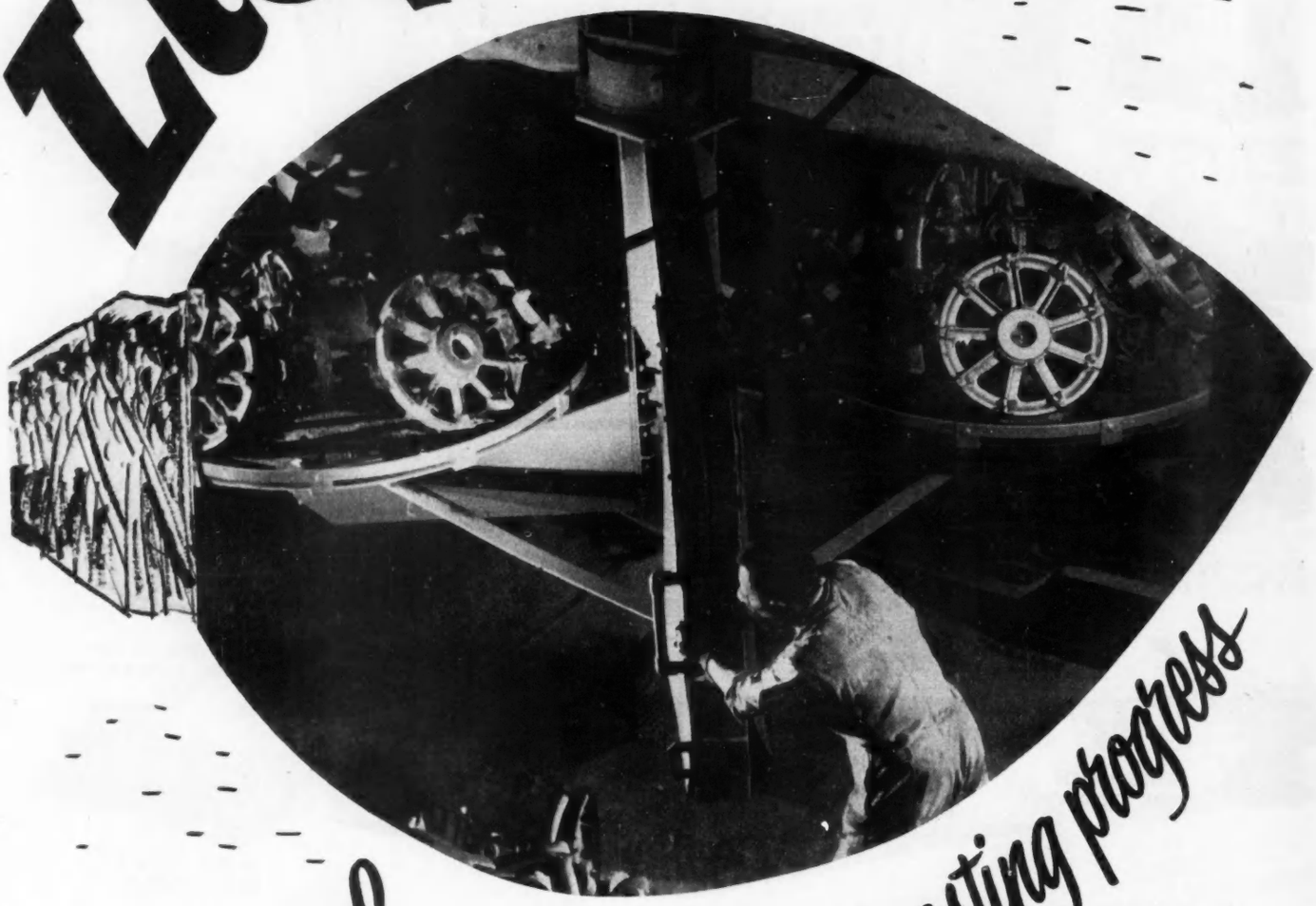

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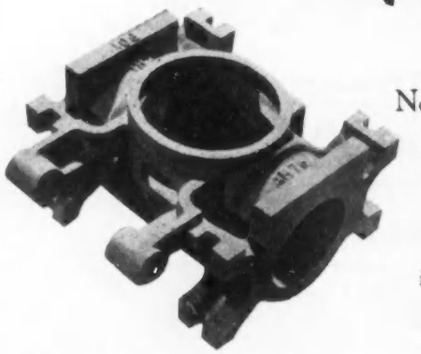

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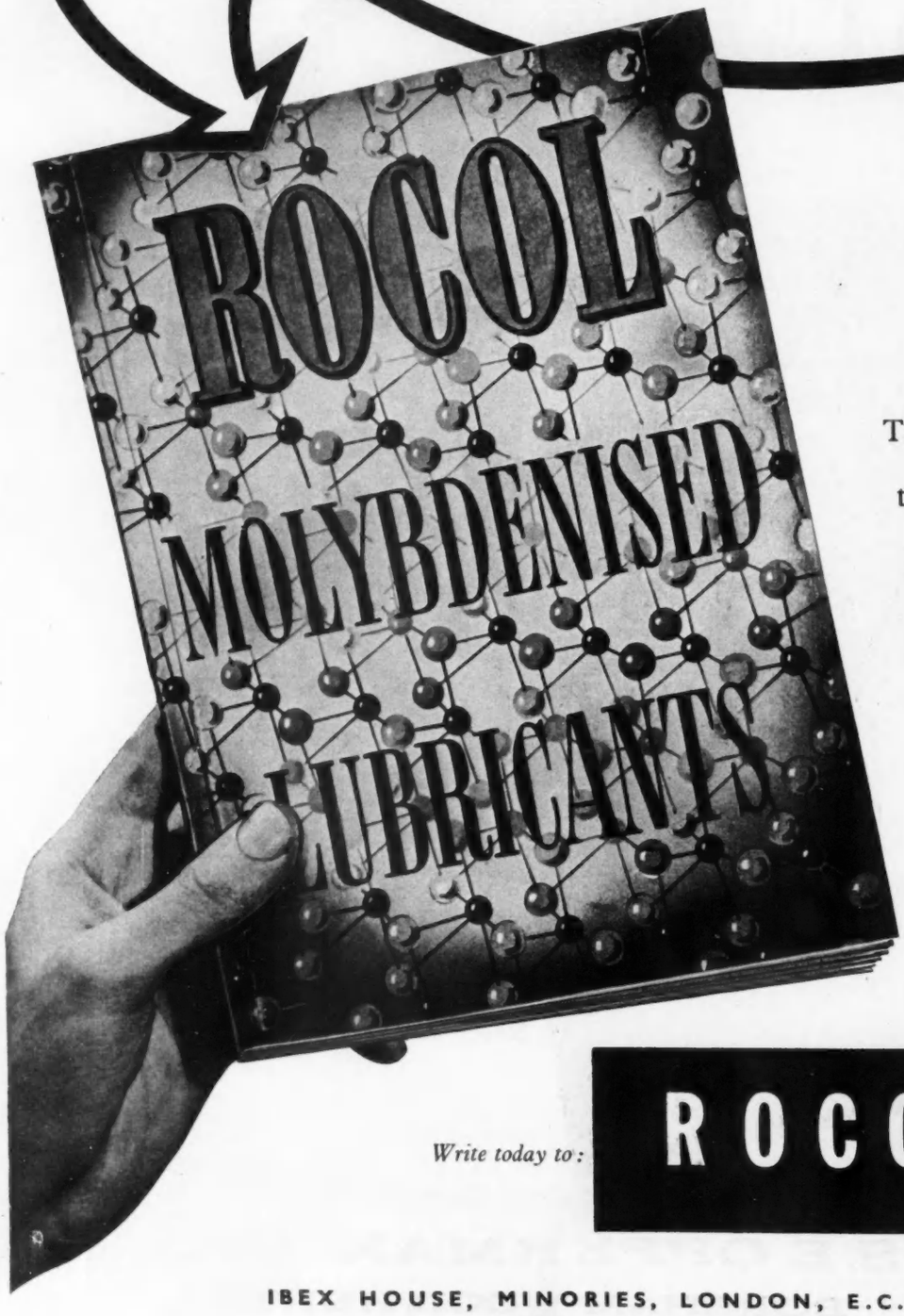

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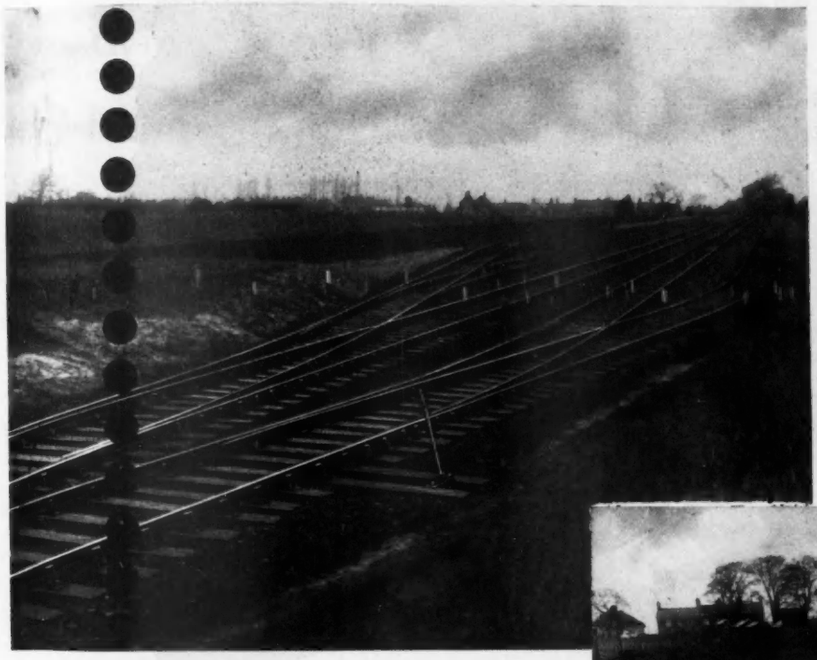

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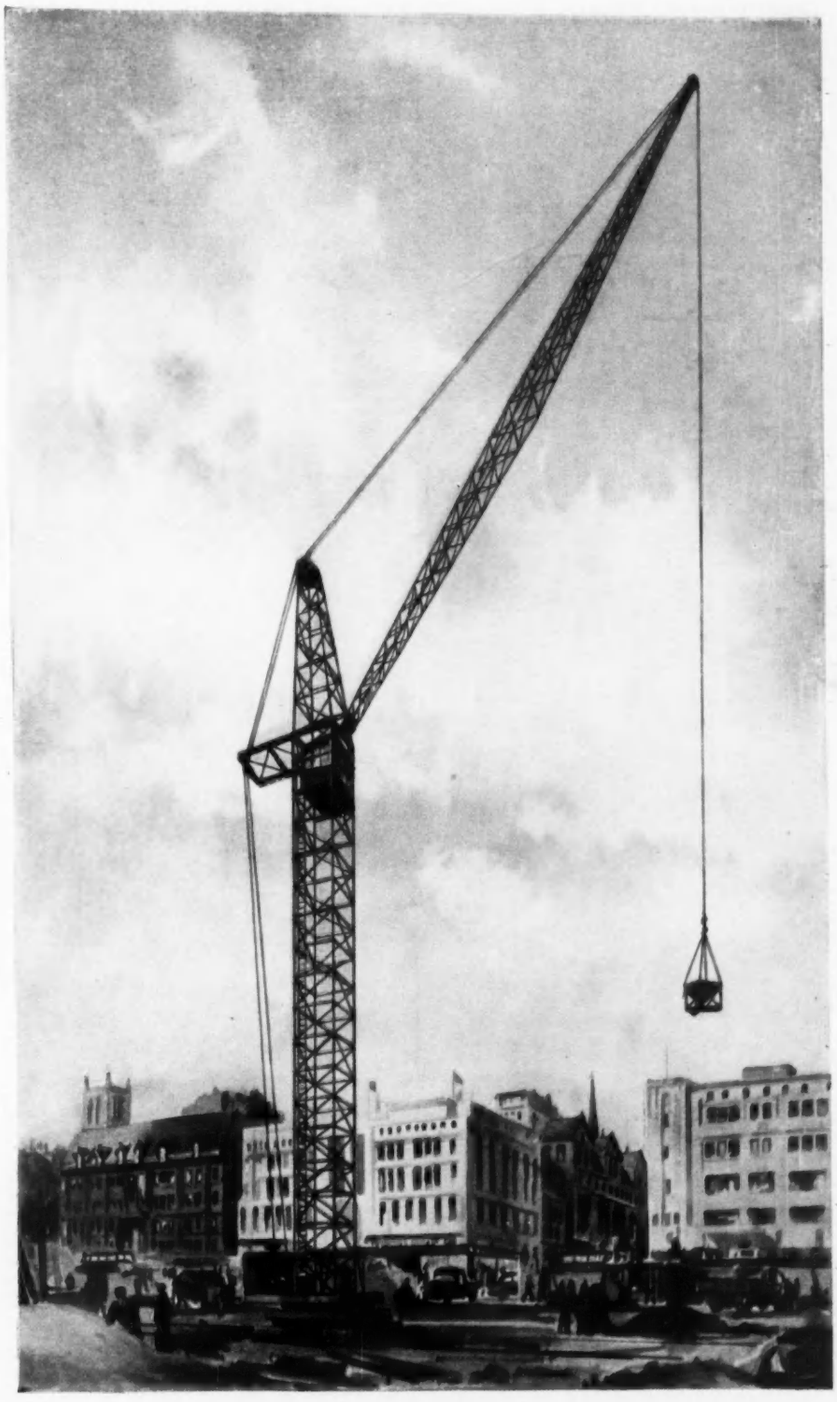
Control, all electric, is effected from high or low position, either from the cabin shown in the illustration or from bottom platform



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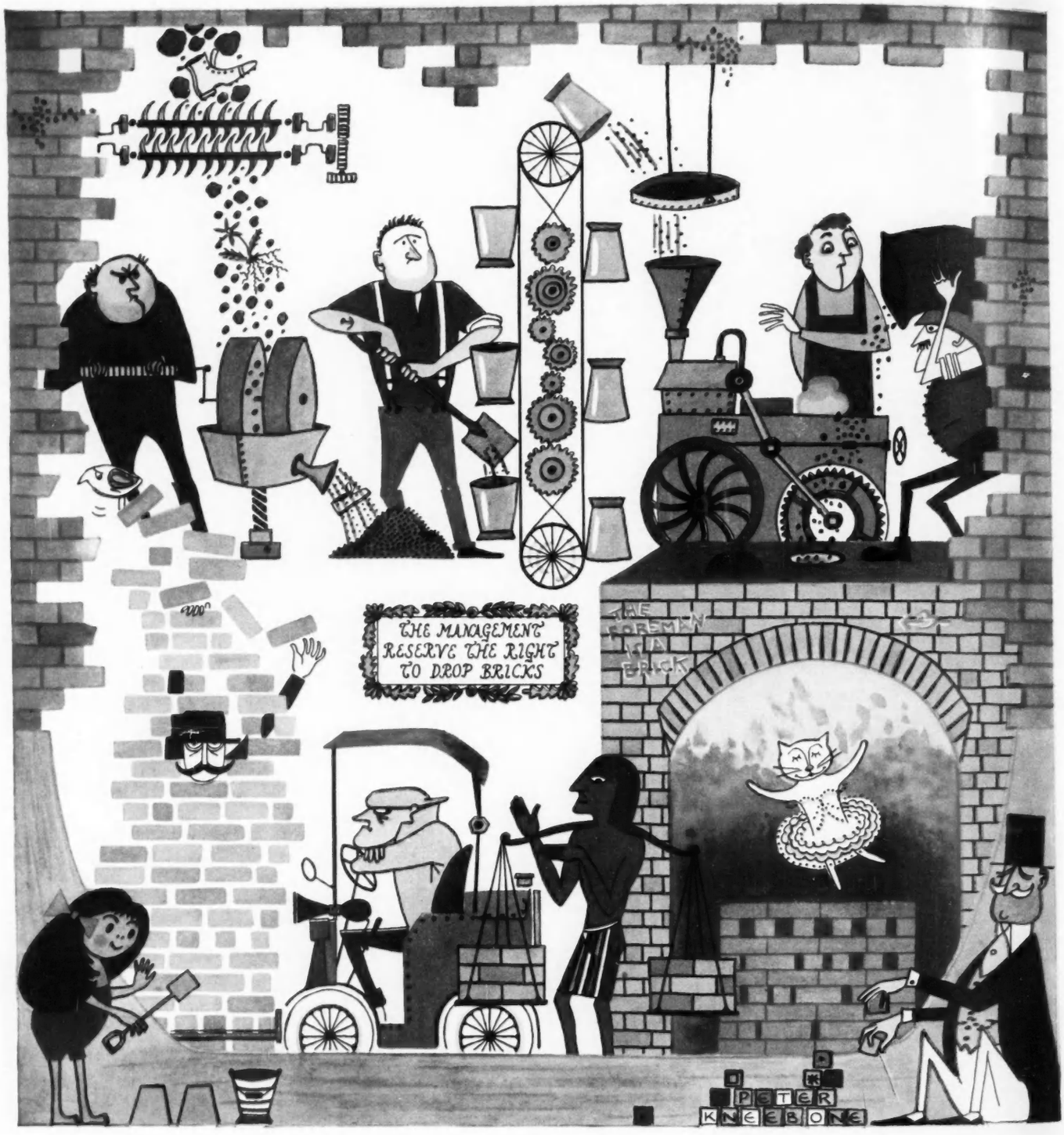

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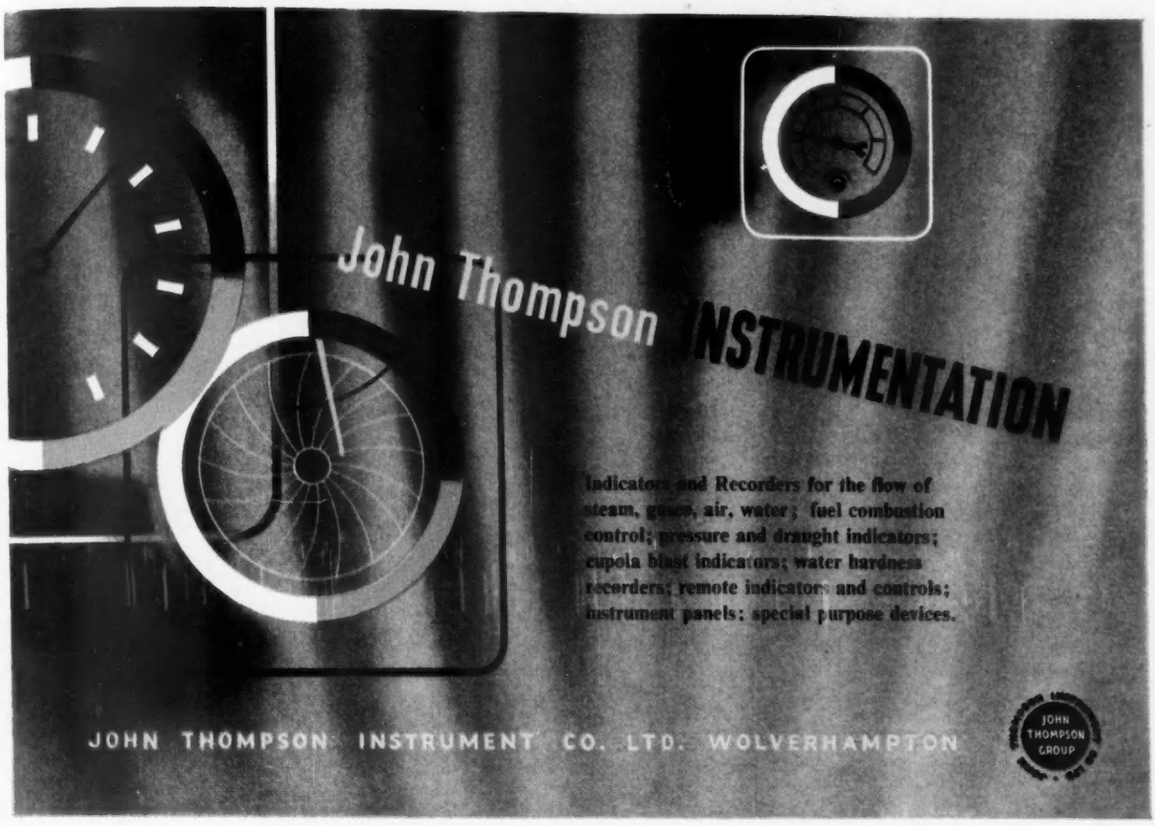
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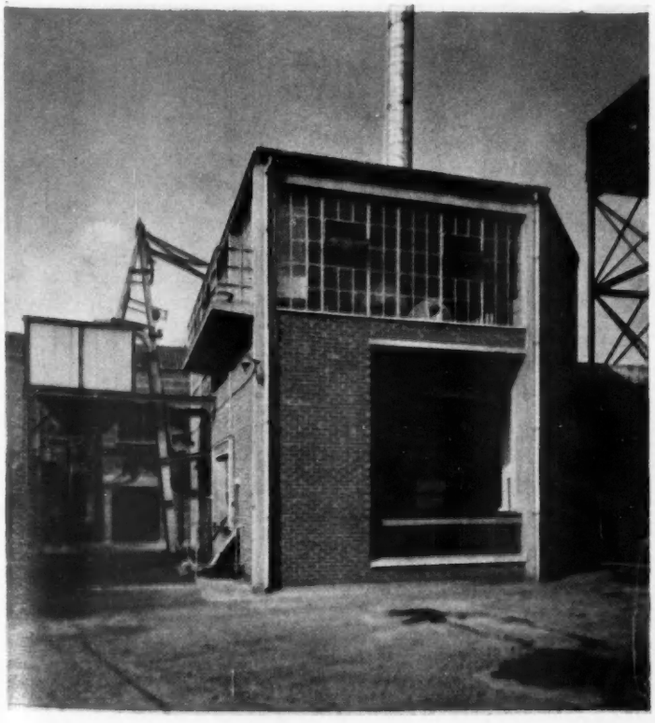

THOMPSON-TRIUMPH STOKERS

and handling plant

The travelling grate stokers of this modern coal-fired steam raising plant together with the well laid-out coal handling equipment and auxiliaries were supplied by John Thompson (Triumph Stoker) Ltd.

The whole plant was designed to operate at high efficiency with reduced maintenance. On test, the efficiency of the boiler, supplied by John Thompson (Wolverhampton) Ltd., proved to be over 83%. First class modern plant of this nature can easily recover the cost of installation in the savings obtained in fuel and services.

Photograph by courtesy of J. Mandleberg & Co. Ltd., Salford.

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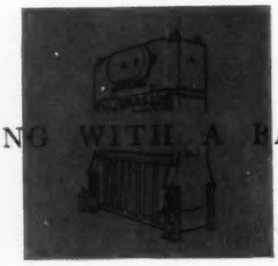
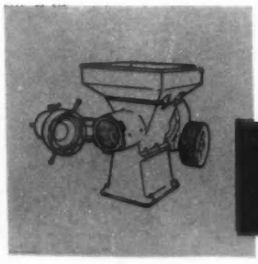


ENGINEERING WITH A BACKGROUND

Axial-flow pumps...

Renowned for their efficiency in the delivery of large volumes of water against comparatively low heads, Vickers-Gill axial-flow pumps owe their success to a background of engineering achievement. History-making aircraft like the Viscount and Valiant . . . fast ocean liners such as the 29,000-ton 'Orsova' . . . these are headline news. Yet, in their own fields, hundreds of lesser-known products of Vickers-Armstrongs are equally important. Whether complex or simple, each shares the same background of outstanding design and sound construction; each solves critical engineering problems.

Vickers-Gill pumps are highly efficient for condenser circulating water, dock de-watering and impounding, irrigation and drainage, waterworks and sewage works duties. Discharge rates vary from 2,000 to 200,000 g.p.m. against heads up to 65-70 ft., and the pump design is extremely compact. Impeller pitch is variable, and the pumps are self-regulating, so that at constant r.p.m. any fall in head below the maximum specified is accompanied by an increased discharge at a decreased power. The same high efficiency is maintained in the multi-stage units — the form in which most Vickers-Gill pumps are used.



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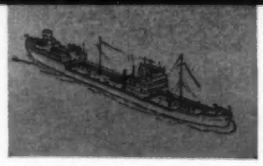

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During the last few years, the British Steel Industry has embarked on a vast expansion programme to increase steel production. John Smith Cranes are playing their part in this programme, and are now used in many of the largest steelworks and rolling mills in the country.

MASTER CONTROLLER EQUIPMENT can be incorporated in our cranes when required. This equipment gives correct acceleration sequence to the various motions, it also provides full electrical protection to all motors on the crane.

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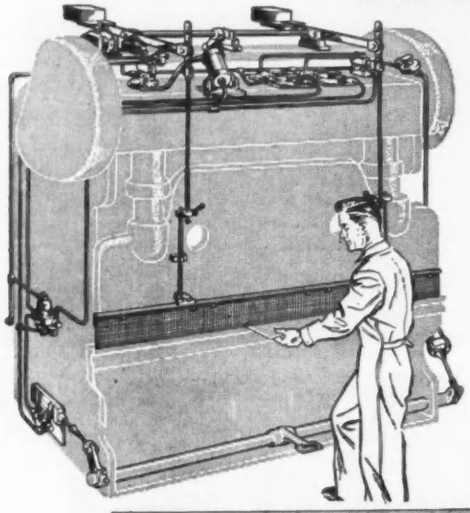
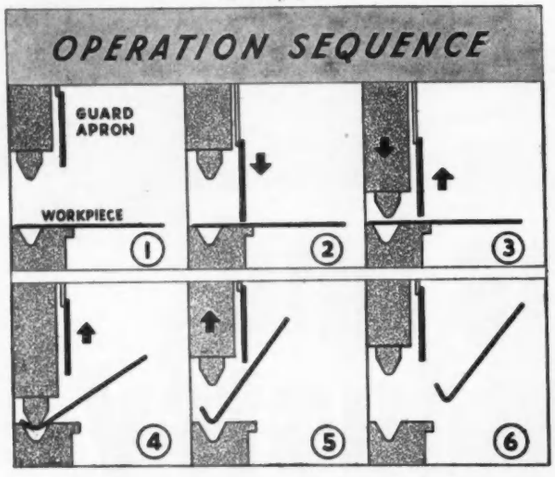
with SAFETY the watchword..





This Pneumatic Press Brake Guard is designed to give the highest degree of safety and efficiency during all pressing operations. It is simple in operation, being coupled to the machine controls, and is adaptable to suit any make of machine. See the Guard in operation at our own factory.

Controlled by an effective pneumatic system, one depression of clutch pedal operates both guard and machine.

1.2. Guard apron descends firstly by gravity to a set tolerance above work-piece and prevents further access to tool space before clutch can be engaged. Guard is locked in down position under air pressure before clutch engages.

3.4. Guard starts to rise immediately tools touch workpiece.

5.6. Workpiece is formed and withdrawn without guard interference.

SPECIAL SAFETY NOTE.—Guard apron is sensitively balanced so that should it fall on operator's hands accidentally, no harm will result. Clutch will also not engage and machine cannot operate.

RUBERY OWEN *Pneumatic* PRESS BRAKE GUARD

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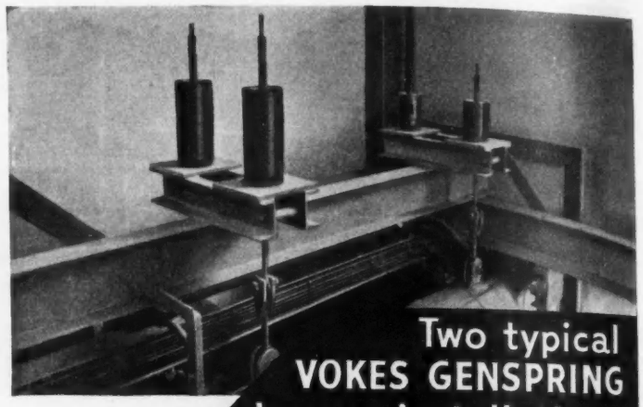
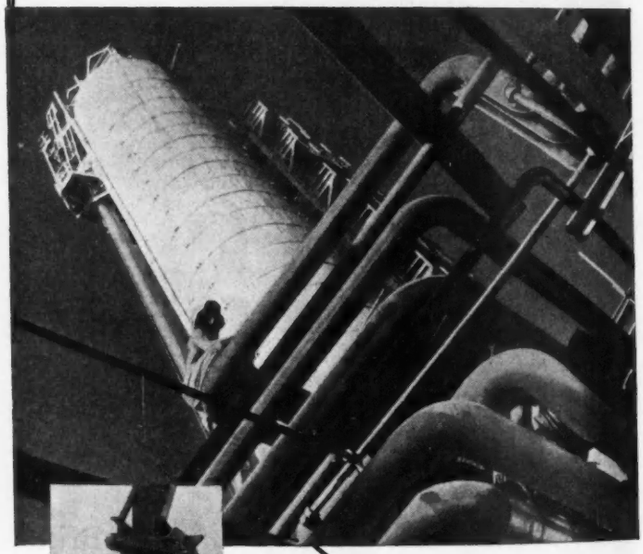


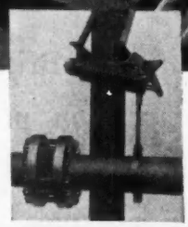
Photograph by courtesy of The Associated Ethyl Company Limited.

Two typical VOKES GENSPRING hanger installations in the oil industry

IN ADEN, The British Petroleum Company's new refinery came on stream in July 1954. Many sections of this complicated process plant piping demand the finest and most accurate suspension methods, and this requirement has been met by the installation of Vokes Genspring Variable Support Hangers. The Associated Ethyl Company Limited have also made use of these Vokes Genspring Hangers at their Ellesmere Port Works in Cheshire.



Photograph by courtesy of The British Petroleum Company Limited.



VOKES GENSPRING Variable Support Hangers are specifically designed for the control of vibration and limited thermal movement of piping, but where piping systems need to be 'floated' to offset the effects of extensive movement, Vokes Genspring Constant Support Hangers should be used. The full range is detailed in the Vokes Genspring catalogues available on request.

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SUSPENSION SYSTEMS

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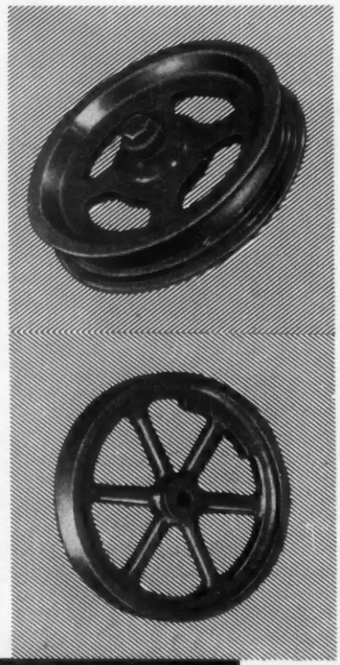
Flywheels and circular castings in cast iron

Front Tractor Wheel



In order to offer competitive prices we have specialized our production in Newcastle upon Tyne. Our foundry and machine shop equipment is most suitable for **Repetition** circular grey iron castings. Flywheels are produced from our own patterns, machined and balanced if desired. Present production covers a range from 6in. to 50in. diameter and from 20 to 1,000 lbs. in weight.

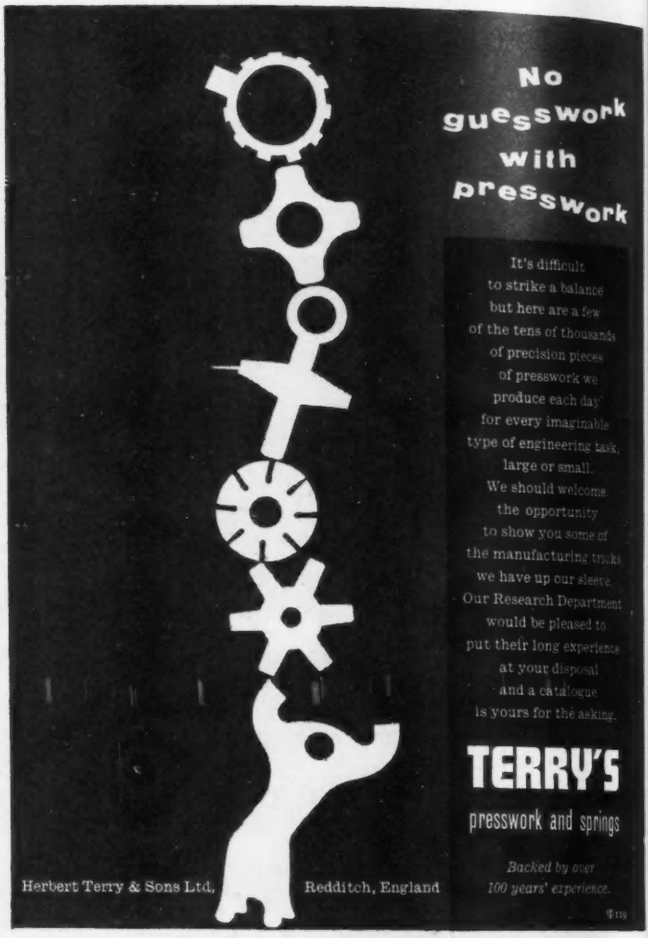
All castings can be shot-blasted if required. Capacity available for any type of pattern making, casting and machining.

Typical Flywheel

FH (NEWCASTLE) LTD *Ironfounders & Engineers*

POTTERY LANE, NEWCASTLE UPON TYNE 1

PHONE: 28291/2/3 TELEGRAMS: WHEELS, NEWCASTLE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presswork and springs
Backed by over 100 years' experience.
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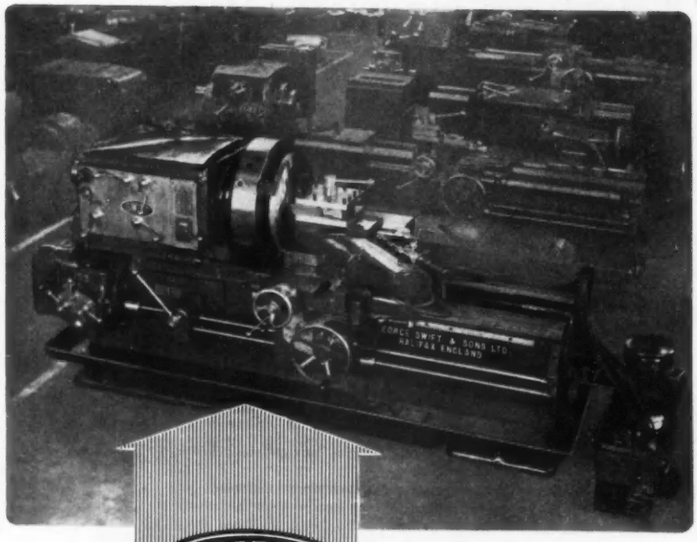

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Cost of dies made with KIRKSITE 'A' is only a fraction of those made of steel or cast iron, the more intricate the tool the greater is the saving. Use of KIRKSITE 'A' also means that dies can be produced in a few days eliminating long waiting periods for tools. A complete and speedy service for the production of both patterns and dies is operated. KIRKSITE 'A' data gladly sent on request. Also the Hoyt Buyers' Guide, listing all the Hoyt products and services.

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200,000	Petrol tank pressings in 20 gauge steel from one KIRKSITE punch.
60,000	Aircraft jettison tanks in 16 gauge steel.
20,000	Delivery van sides in 20 gauge steel.
20,000	Runs in aluminium alloy sheet without any appreciable wear on tools.
50,000	Special plastic helmets on one set of KIRKSITE tools.
25,000	Special rubber parts from a KIRKSITE mould.

All the above tools were still serviceable

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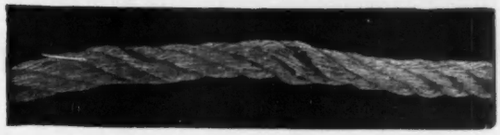
Give your Ropes a chance

NUMBER FOUR

(Fig. 2). *This Rope was used on the Pulley shown in Fig. 1*



PULLEYS and SHEAVES

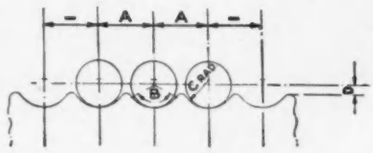
1. Check your pulleys and sheaves frequently for wear and alignment and true them up.
2. Your pulleys and sheaves should be made of hard metal — Soft metal wears and takes on an imprint of the rope—The imprint will fit the old rope, *not* the new one.
3. Many pulleys and sheaves can be case hardened in the groove—If this is not possible in your case specify manganese steel or similar material for your new ones.

   Don't let this happen ! See Fig. 1.
4. Check your sheave and pulley bearings for wear and see that they are lubricated.
5. Flats develop on sheaves and pulleys through usage and start vibration—so use your calipers and be sure that they are round.

(Fig. 1) Cross Section of a Jib Head Pulley showing uneven wear—Result (See Fig. 2)

GROOVING OF DRUMS AND PULLEYS FOR CRANES

On a grooved drum the correct size of rope to fit the grooves may be found by the following table :—



DETAIL OF BARREL AND PULLEY GROOVING FOR WIRE ROPES

WIRE ROPE DIA.	WIRE ROPE CIRC.	A	C	D
5/16"	1"	3/8"	3/16"	1/16"
3/8"	1 1/8"	7/16"	3/16" + 1/32"	1/16"
7/16"	1 1/4" & 1 3/8"	1/2"	1/4"	1/16"
1/2"	1 1/2" & 1 5/8"	9/16"	1/4" + 1/32"	3/32"
9/16"	1 3/4"	5/8"	5/16"	3/32"
5/8"	1 7/8" & 2"	11/16"	5/16" + 1/32"	3/32"
11/16"	2 1/8"	13/16"	3/8" + 1/64"	3/32"
3/4"	2 1/4" & 2 3/8"	7/8"	7/16" − 1/64"	1/8"
13/16"	2 1/2"	15/16"	7/16" + 1/64"	1/8"
7/8"	2 5/8" & 2 3/4"	1"	1/2" − 1/64"	1/8"
15/16"	2 7/8" & 3"	1 1/16"	1/2" + 1/32"	1/8"
1"	3 1/8"	1 1/8"	9/16"	5/32"
1 1/16"	3 1/4"	1 3/16"	9/16" + 1/32"	5/32"
1 1/8"	3 1/2"	1 1/4"	5/8"	3/16"
1 3/16"	3 5/8"	1 5/16"	11/16"	3/16"
1 1/4"	3 3/4" & 3 7/8"	1 3/8"	3/4" − 1/32"	7/32"
1 5/16"	4" & 4 1/8"	1 7/16"	3/4"	7/32"
1 3/8"	4 1/4" & 4 3/8"	1 1/2"	3/4" + 1/32"	1/4"
1 7/16"	4 1/2" & 4 5/8"	1 9/16"	13/16"	1/4"
1 1/2"	4 3/4"	1 5/8"	7/8" − 1/32"	1/4"
1 9/16"	4 7/8" & 5"	1 11/16"	7/8"	9/32"
1 5/8"	5 1/8"	1 3/4"	7/8" + 1/32"	9/32"
1 3/4"	5 1/4" & 5 1/2"	1 7/8"	1" − 1/32"	9/32"
1 7/8"	5 3/4" & 6"	2"	1" + 1/32"	5/16"

B = ANGLE OF BEARING = 120°

The Grooving in the table alongside conforms to B.S.S. No. 302-1938 and is suitable for all constructions of steel wire ropes for Cranes. The figures shown are applicable to both drums and pulleys.

N.B.—*In all cases* the rope is supported by the groove for one-third of its circumference, *i.e.*, Angle of Bearing = B. The grooves should be smoothly finished and the edges round.

Pulley grooves should be one and a half times the diameter of the rope in depth.

The angle of flare of the sides of the pulley groove should be 52°. The corresponding flare on a Vee Grooved traction sheave should be, in general, 42°. If the rope is too large for the grooves the strands will become crushed and deformation will follow, resulting in birdcaging and the very rapid deterioration of the rope. Should, however, the grooves be too large for the rope, it will tend to flatten under load as it will have no lateral support.

Drum and Pulley Diameters for some of the more usual Constructions of Crane Ropes

MINIMUM DRUM OR PULLEY DIAMETERS AT THE BOTTOM OF THE ROPE GROOVE

(C—Circumference of Rope)
(—Diameter of Rope)

4/37 Construction	6/19 Construction	6/24 Construction	6/37 Construction	6/61 Construction
8.5 x C 27.0 x D	7.5 x C 23.5 x D	7.0 x C 22.0 x D	6.0 x C 19.0 x D	5.5 x C 17.0 x D

THE ABOVE TABLE CONFORMS TO B.S.I. 302—1938

N.B.—The above Drum Diameters are based on a maximum Rope Speed of 200 ft. per minute. For each increase of 100 ft. per minute in excess of 200 ft. per minute add 5% to the drum diameter. These tables give minimum drum and pulley diameters which may be safely increased when expedient.

Whenever possible Pulleys should be larger than drums. The angle of lead, that is the inclination of the rope to a plane perpendicular to the axis of the drum, should not exceed 5° (1 in 12).

Remember.—Rope life largely depends on the size and condition of your drums and pulleys.

MARTIN, BLACK & CO. (WIRE ROPES) LTD.

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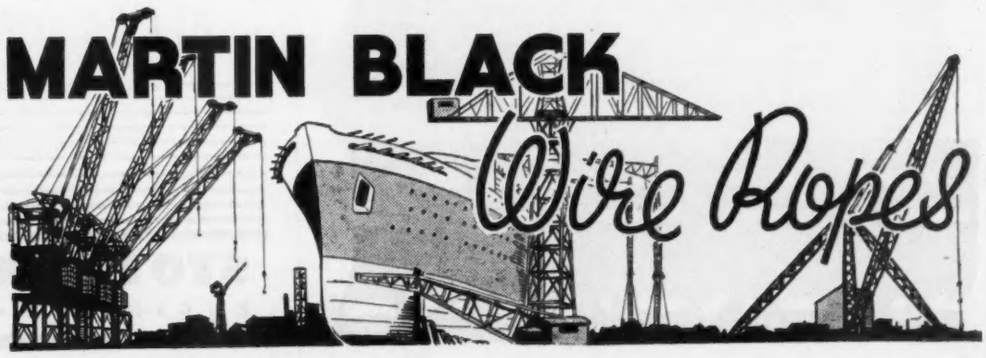

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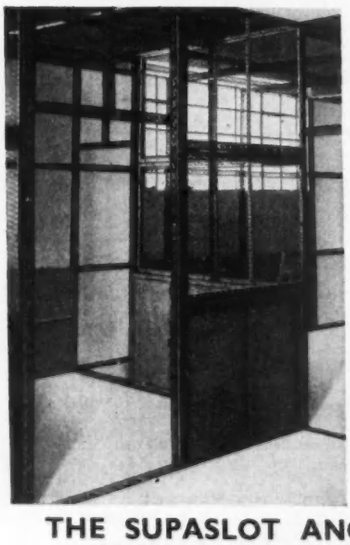

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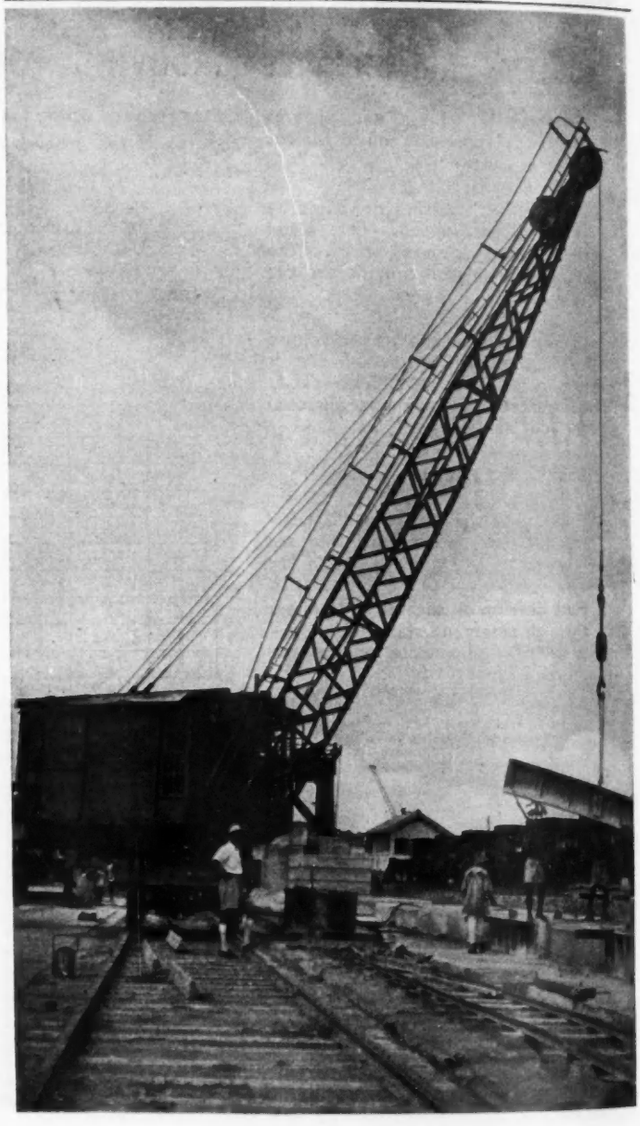

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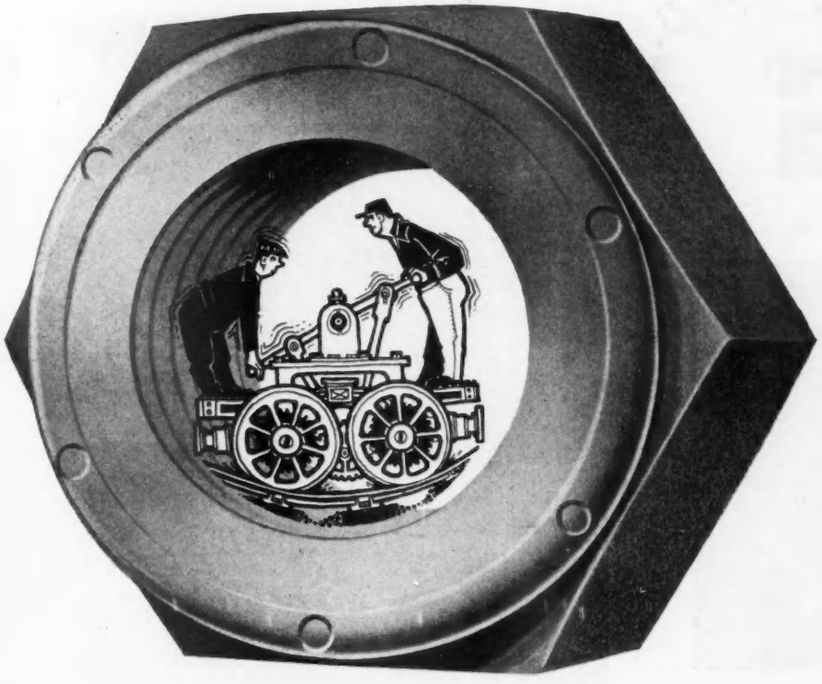

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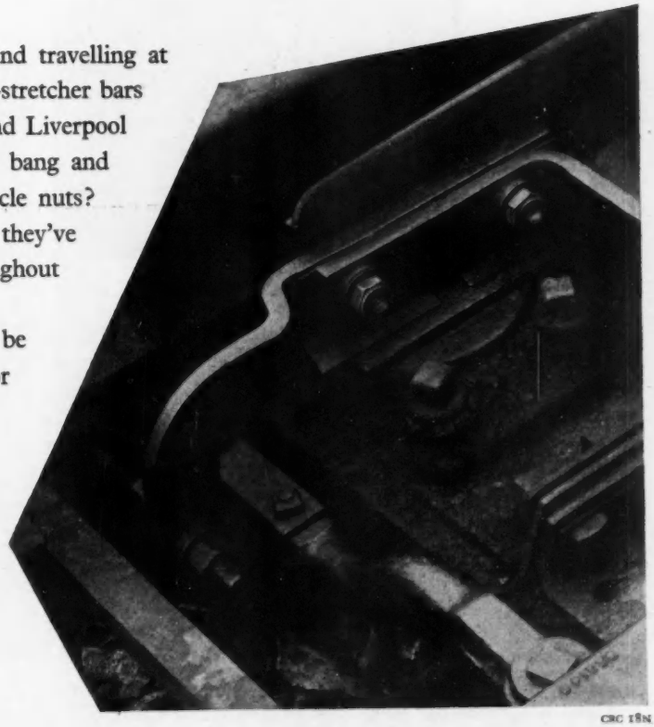
No, nothing—not even trains weighing up to 600 tons and travelling at around 70 m.p.h.! Pinnacle nuts are fitted to the solid lock-stretcher bars of 'points' on the British Railways lines in the Stratford and Liverpool Street areas. Every few minutes steam and electric trains bang and clatter over these points—and what happens to the Pinnacle nuts? They stay put—they don't even budge a thou! That's why they've now been accepted as standard for this application throughout the Eastern Region of British Railways.

Equally tenacious are our Nyloc and Fibre nuts. We'll be glad to advise you which type of self-locking nut is best for *your* job.



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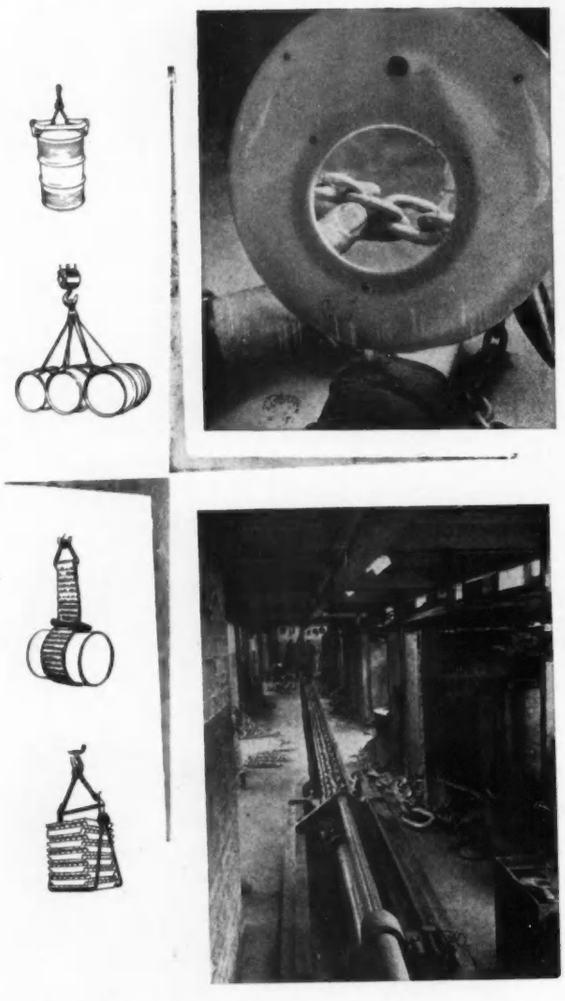

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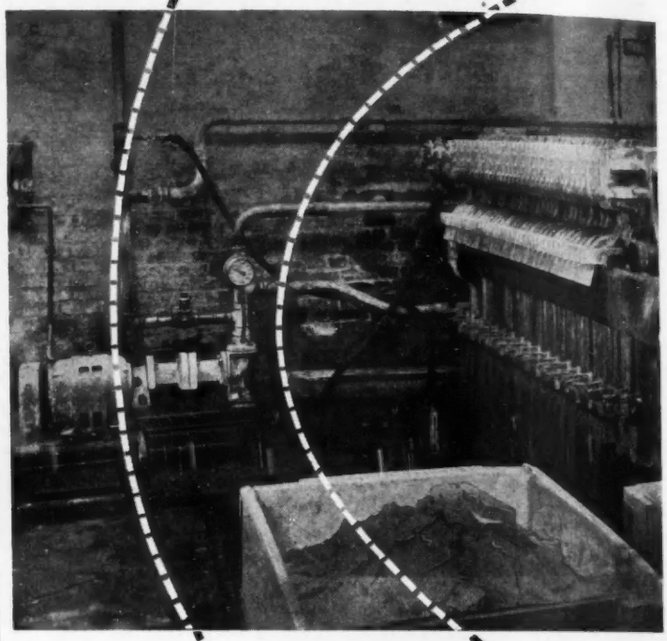

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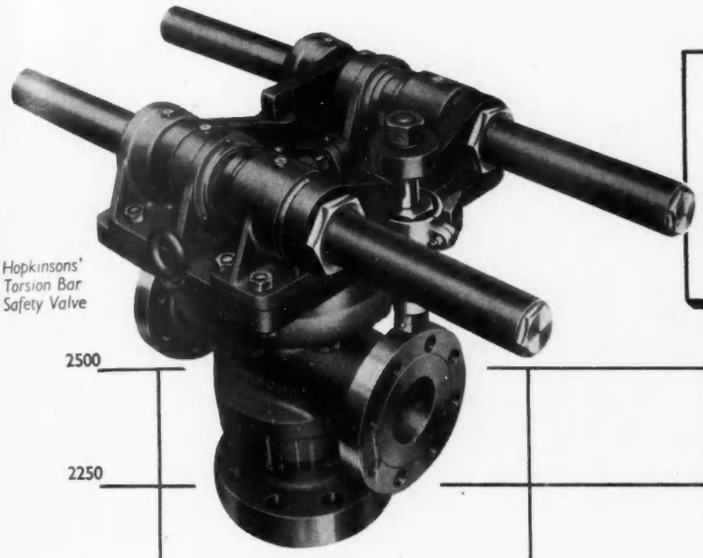

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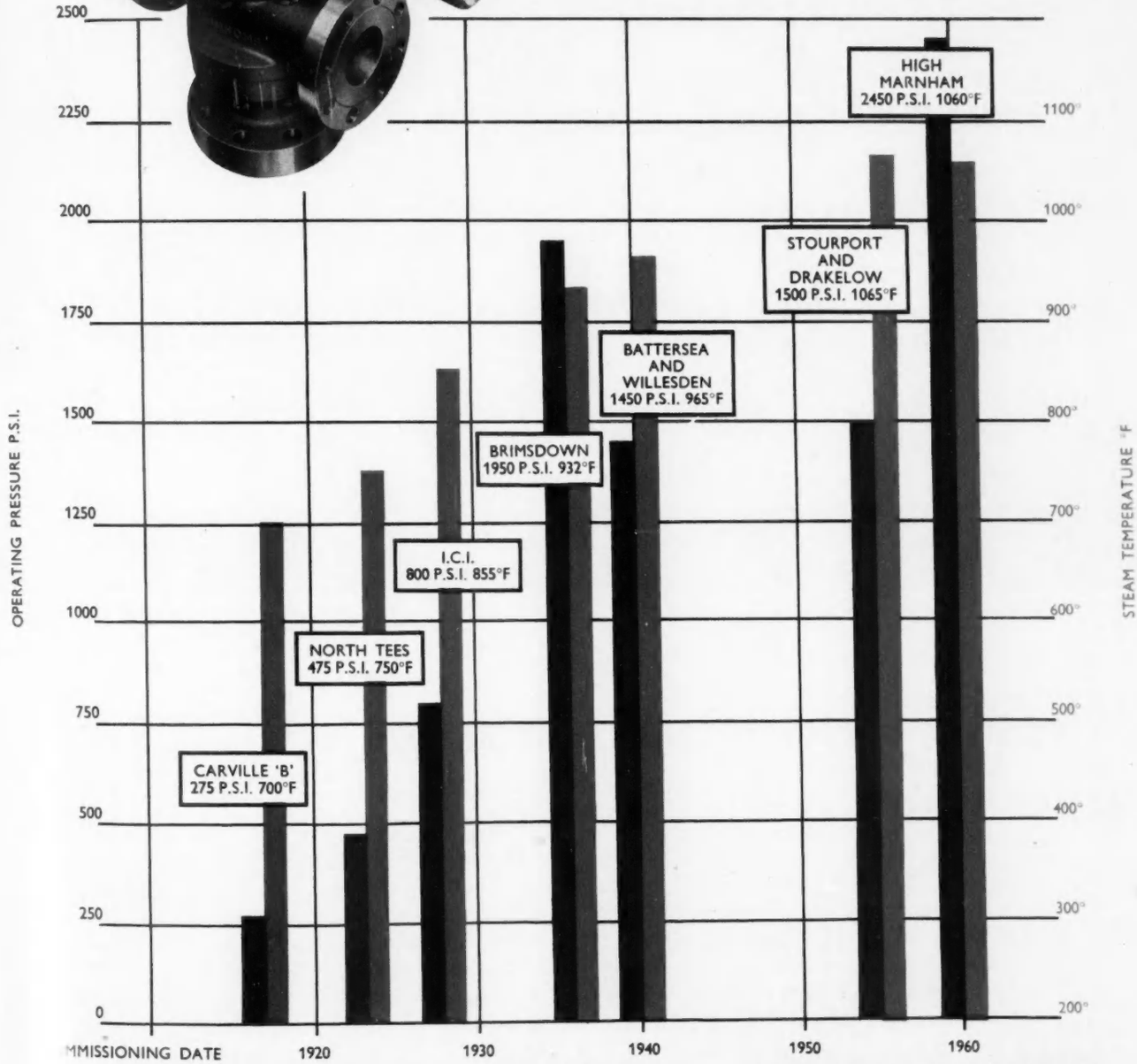

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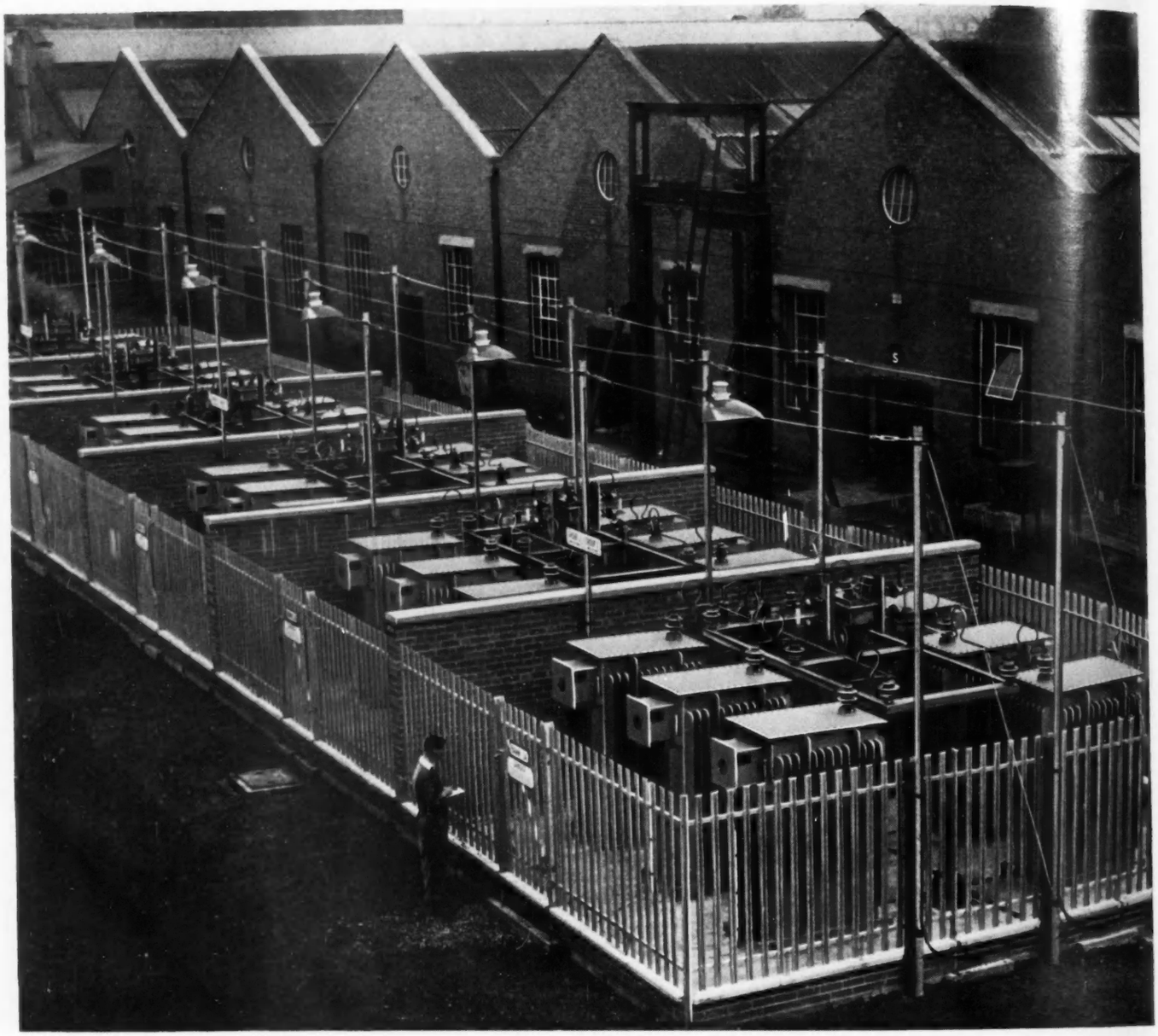

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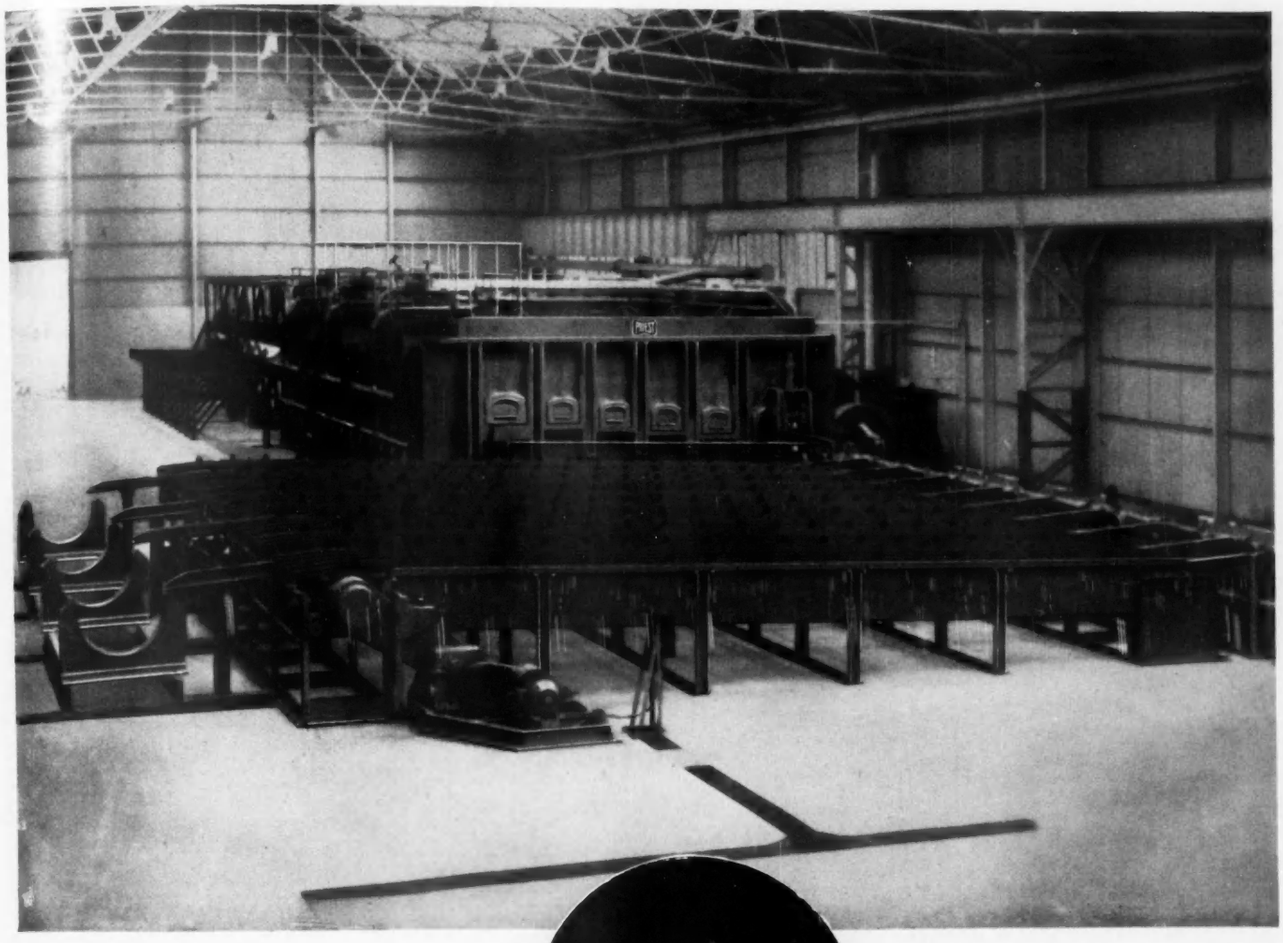

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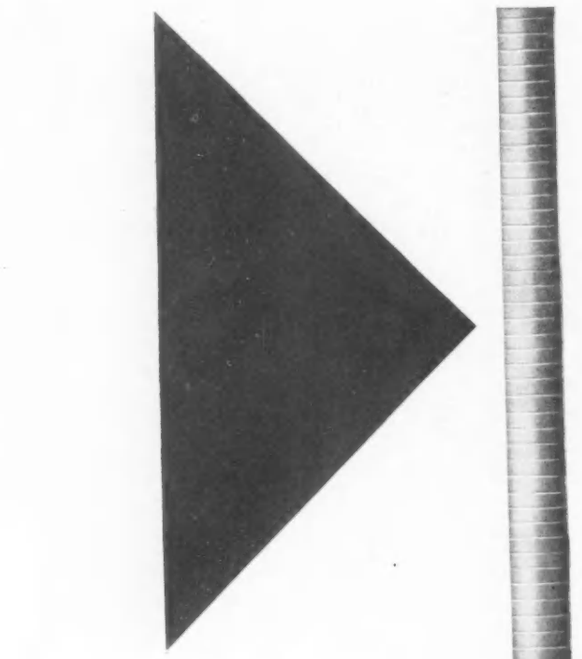

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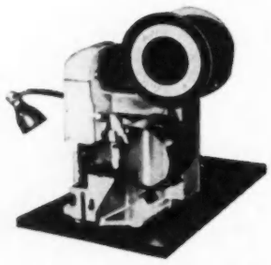

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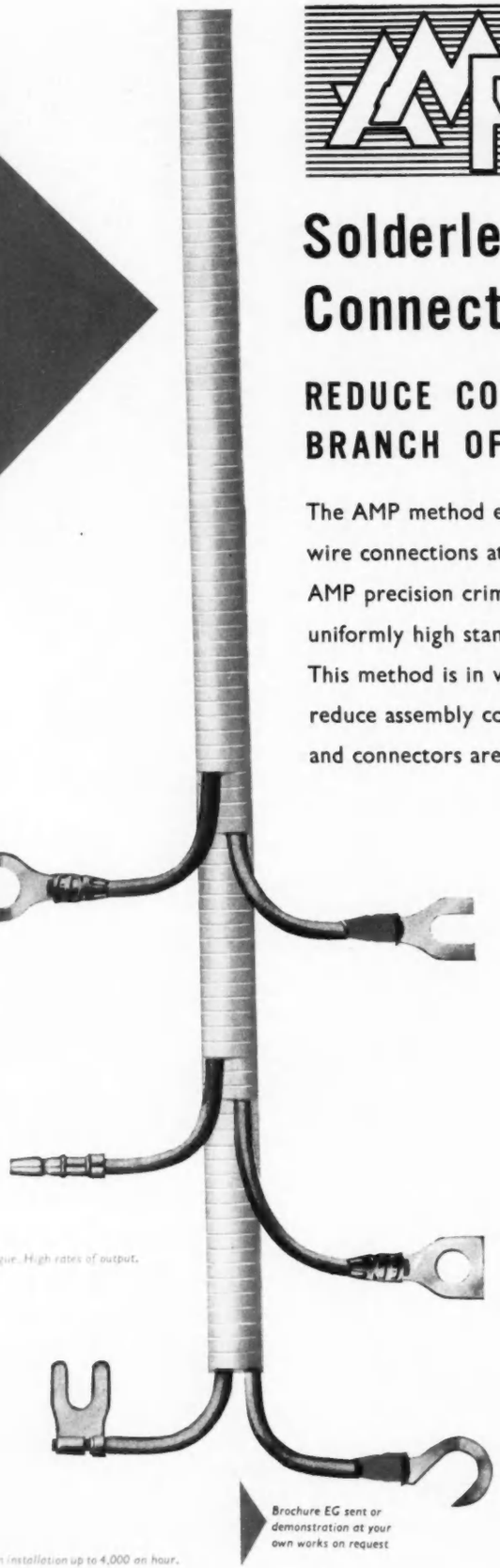

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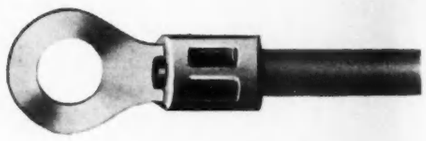

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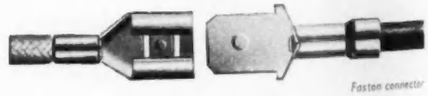
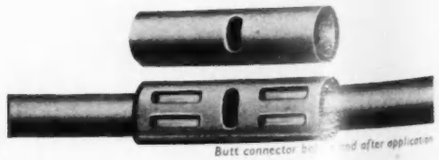


Faston connector



Butt connector before and after application

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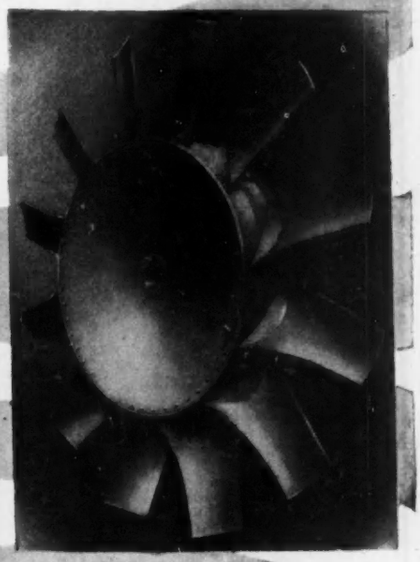

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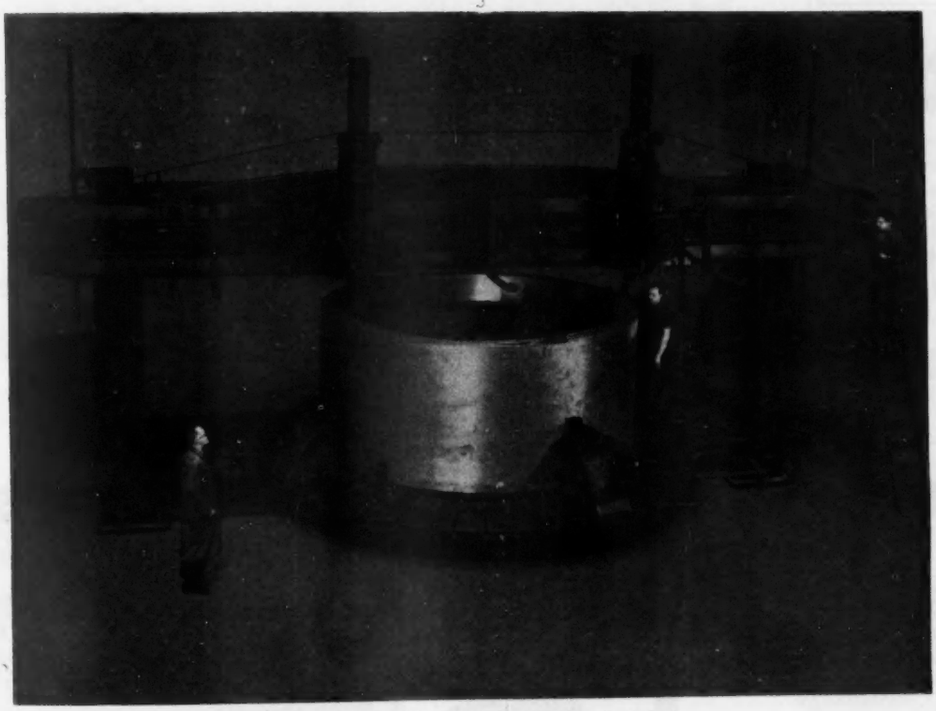

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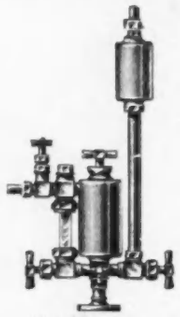

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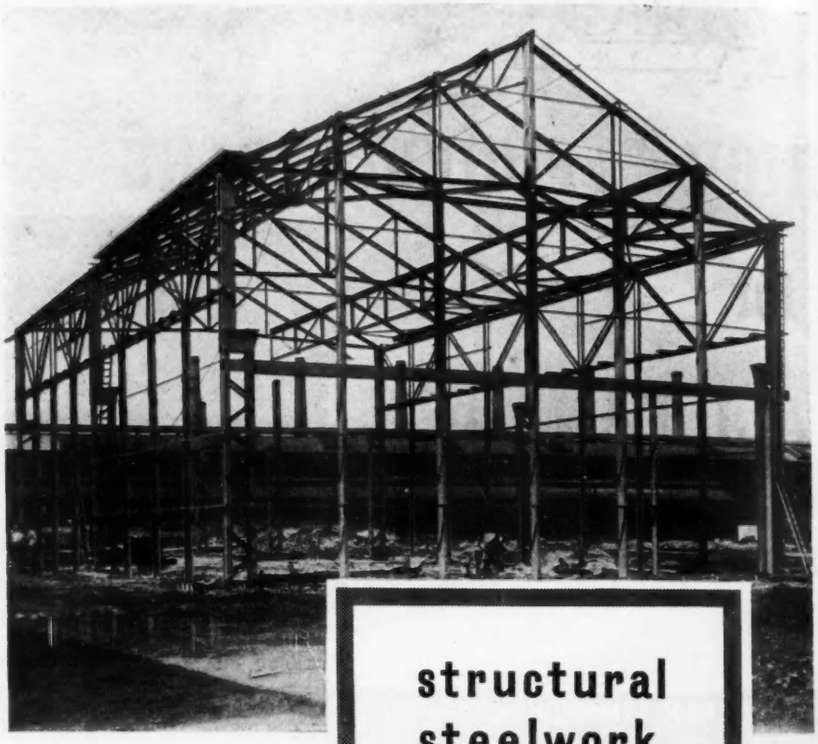

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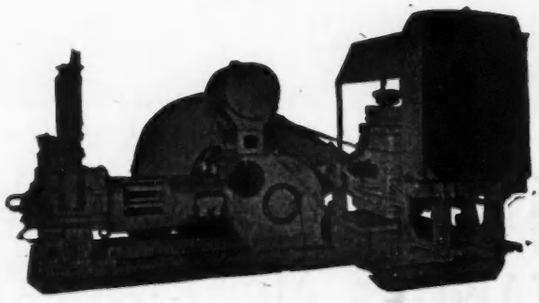

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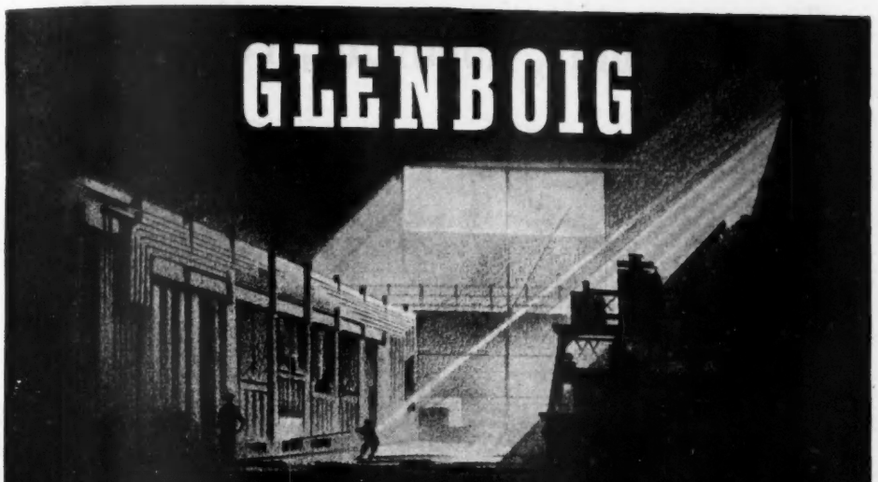

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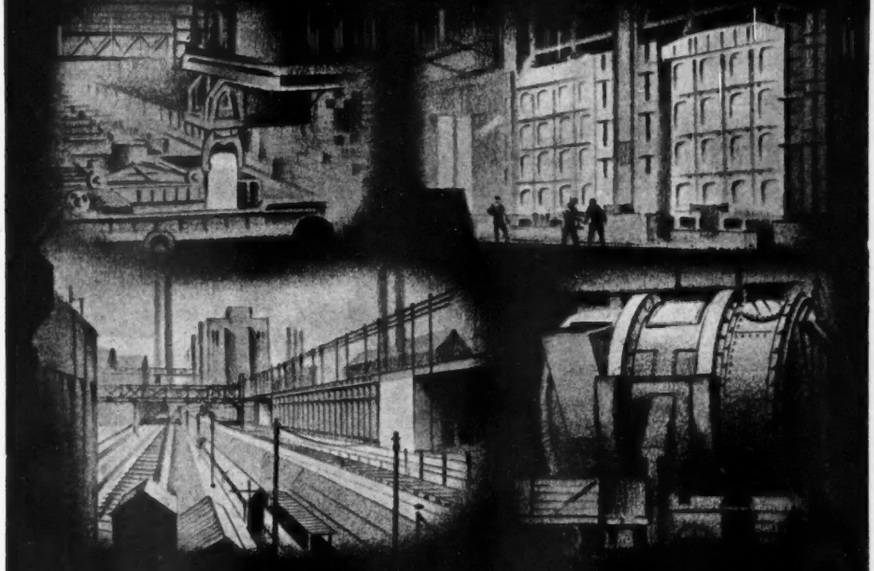

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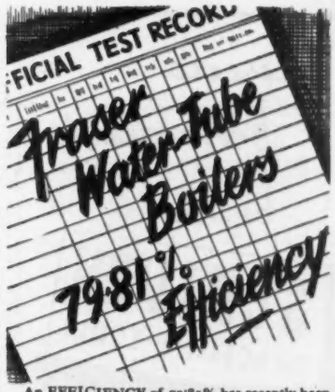

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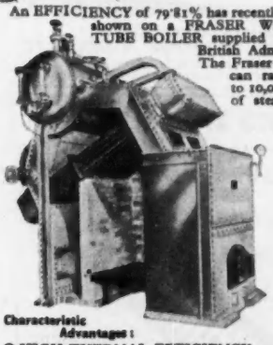

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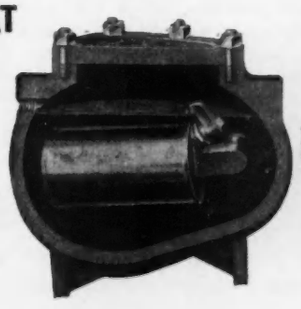

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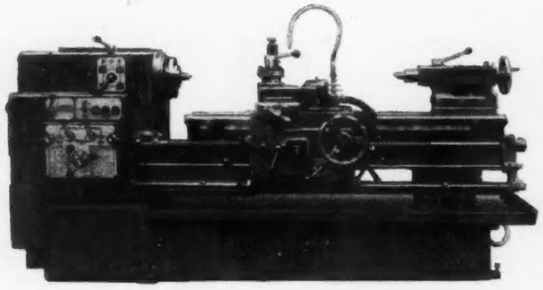

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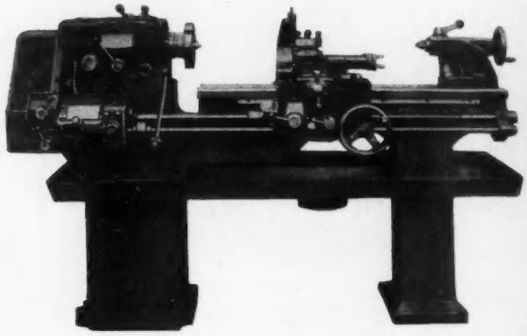

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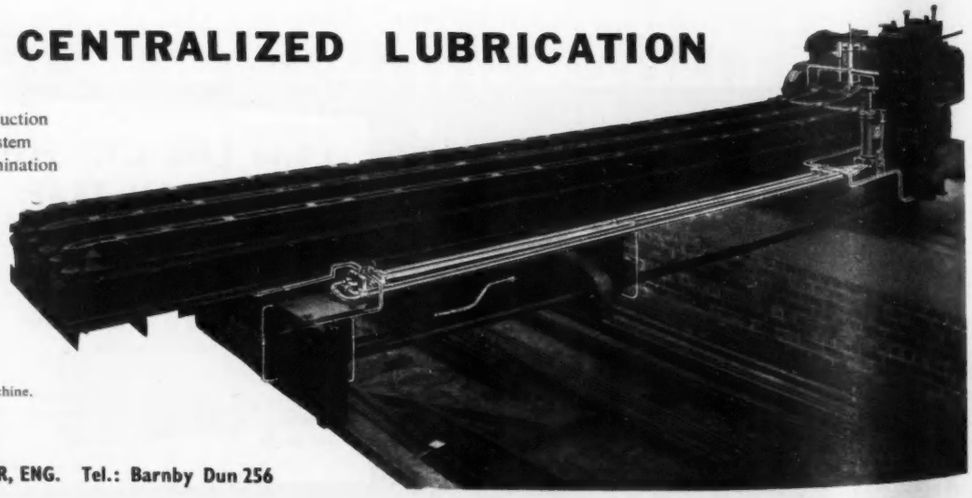

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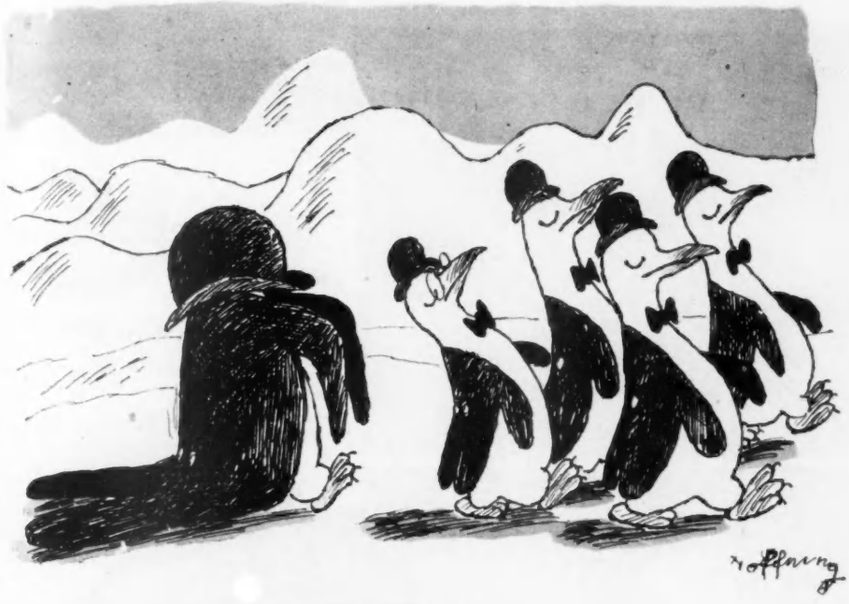

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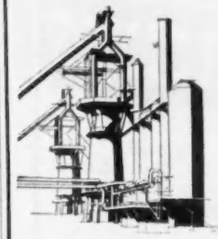

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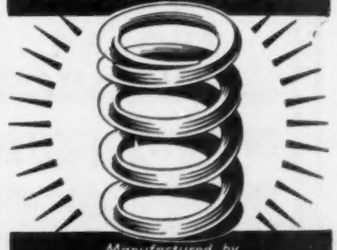

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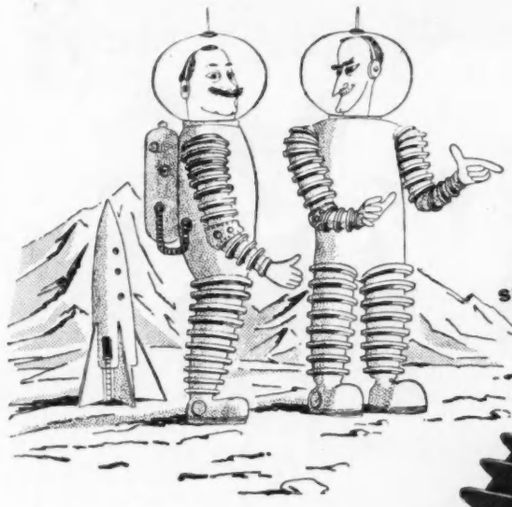

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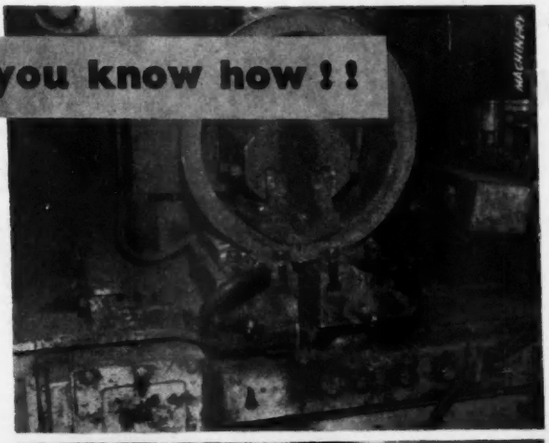

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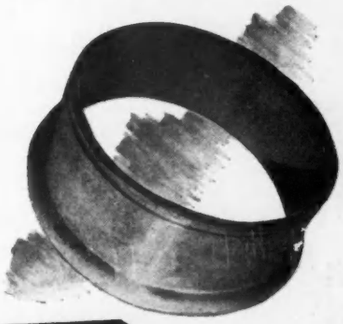

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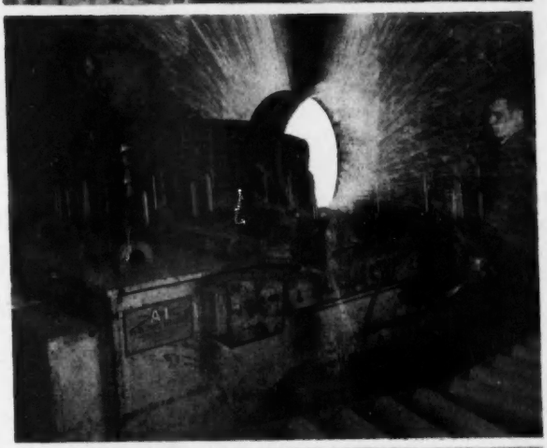

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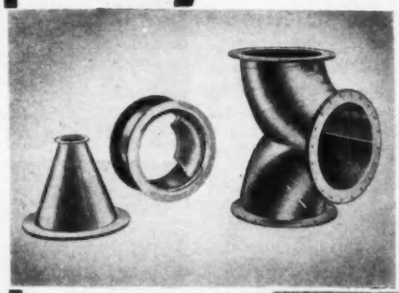

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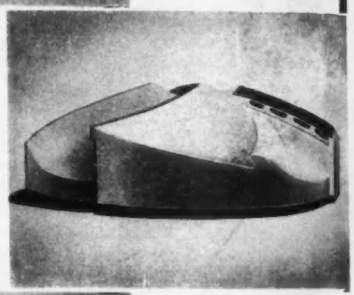

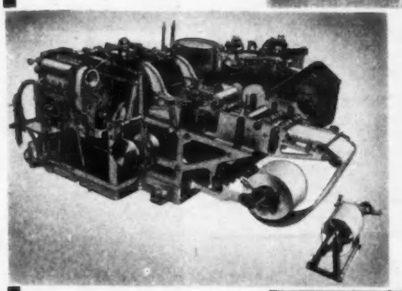

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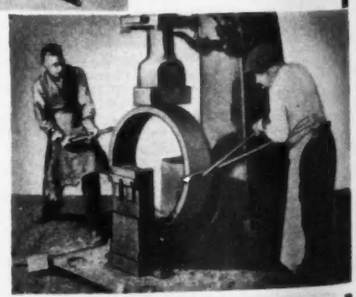

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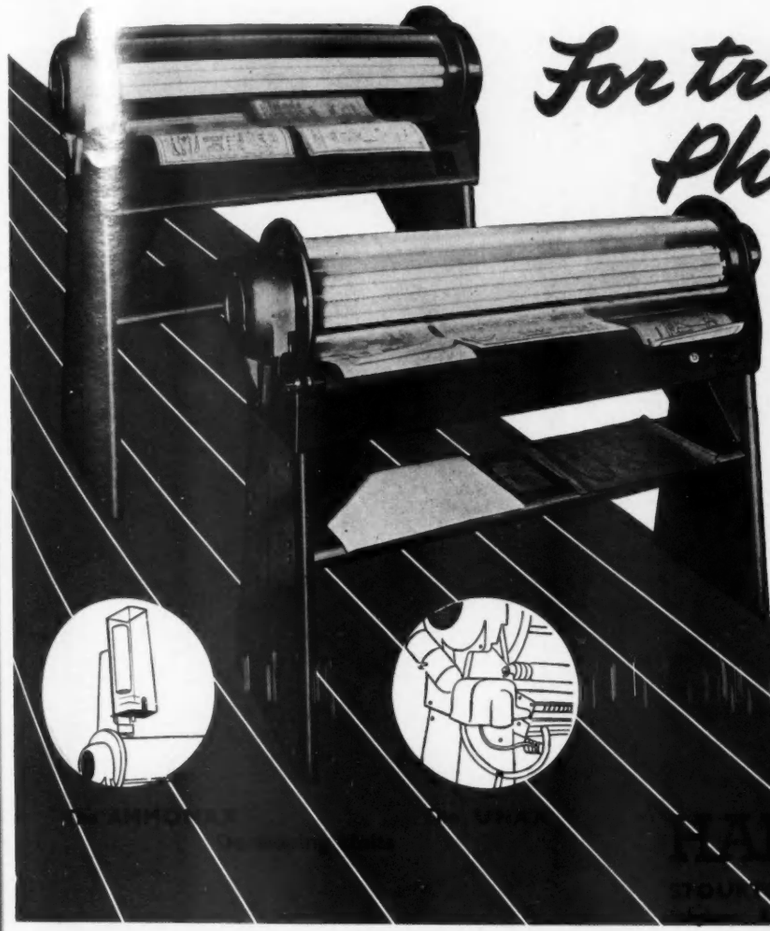

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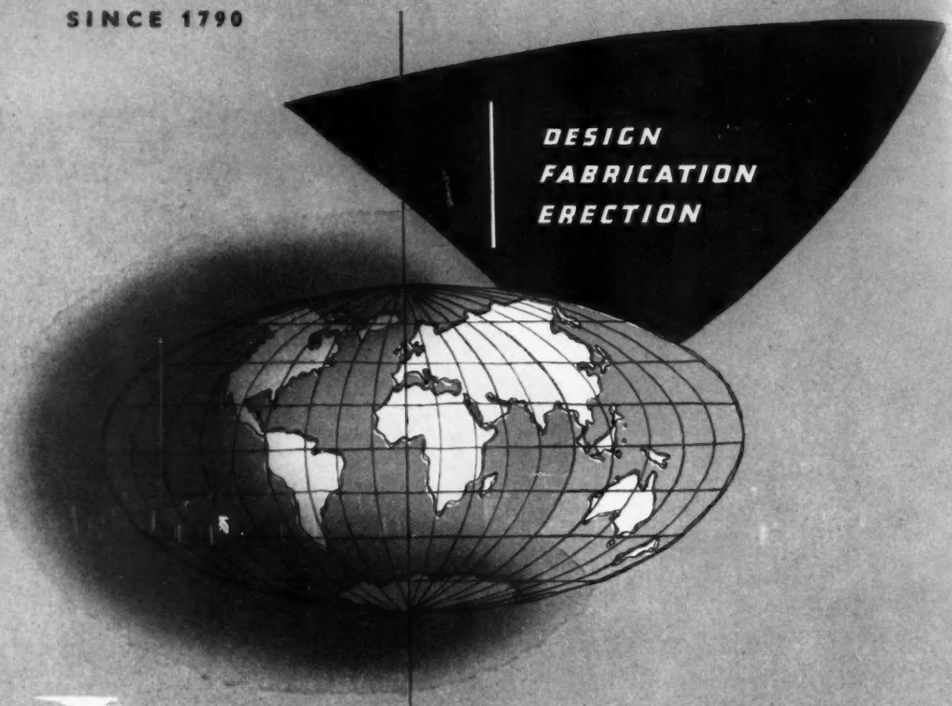

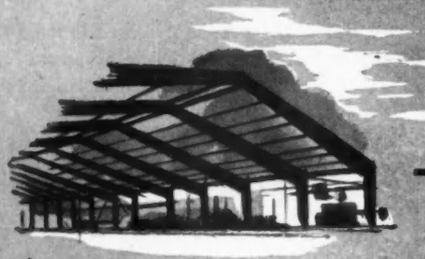

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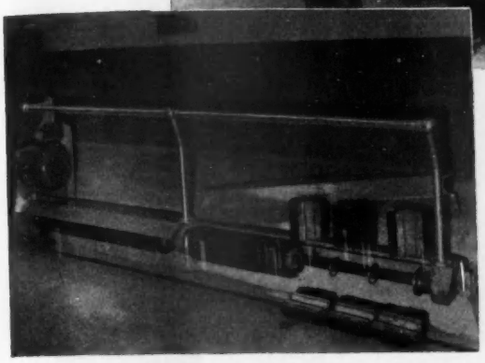

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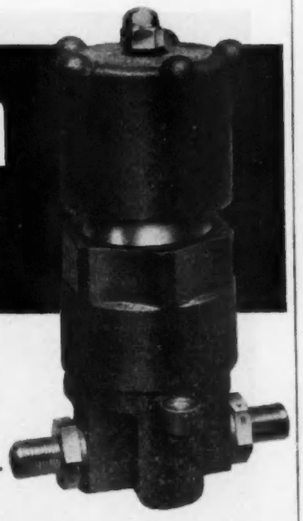

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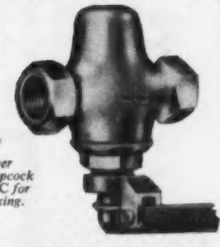

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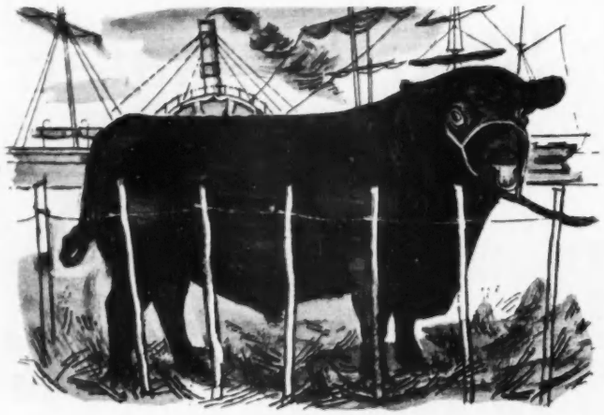

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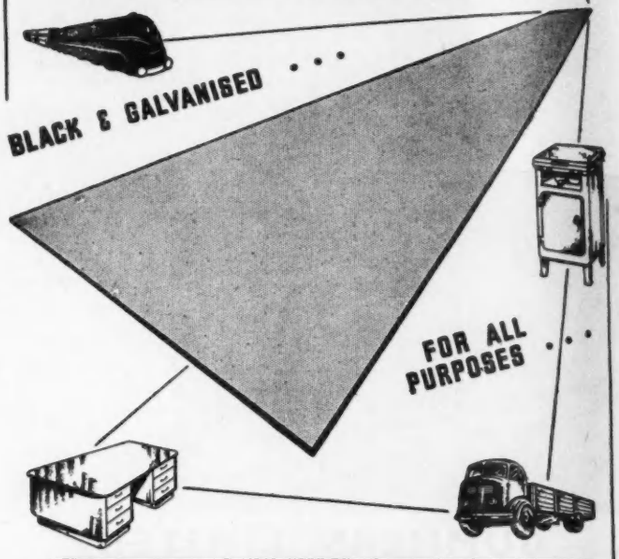

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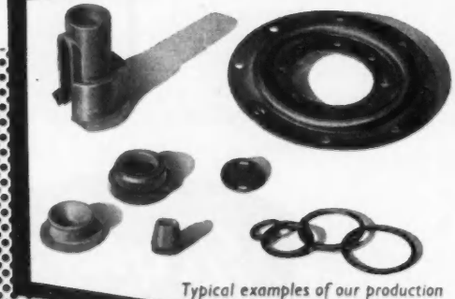

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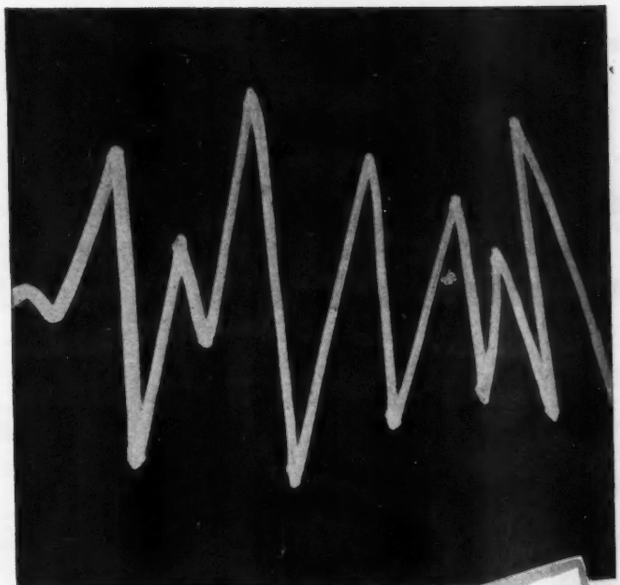

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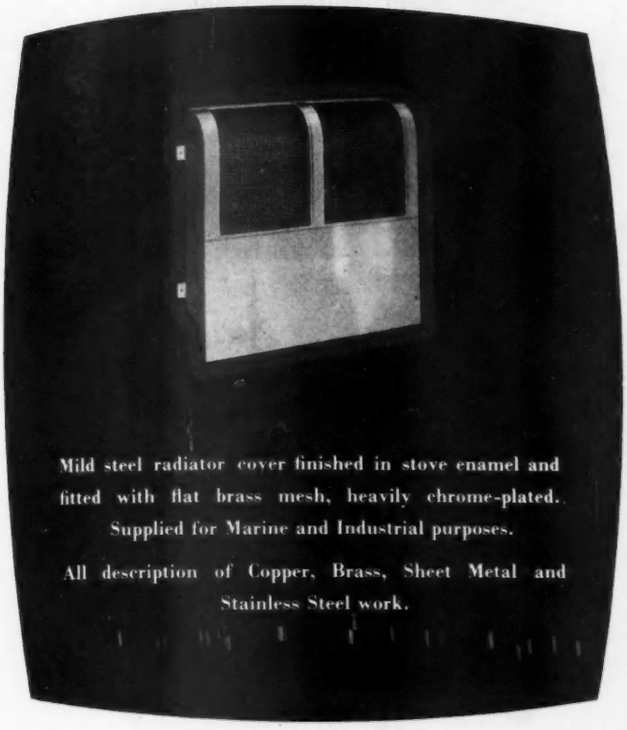

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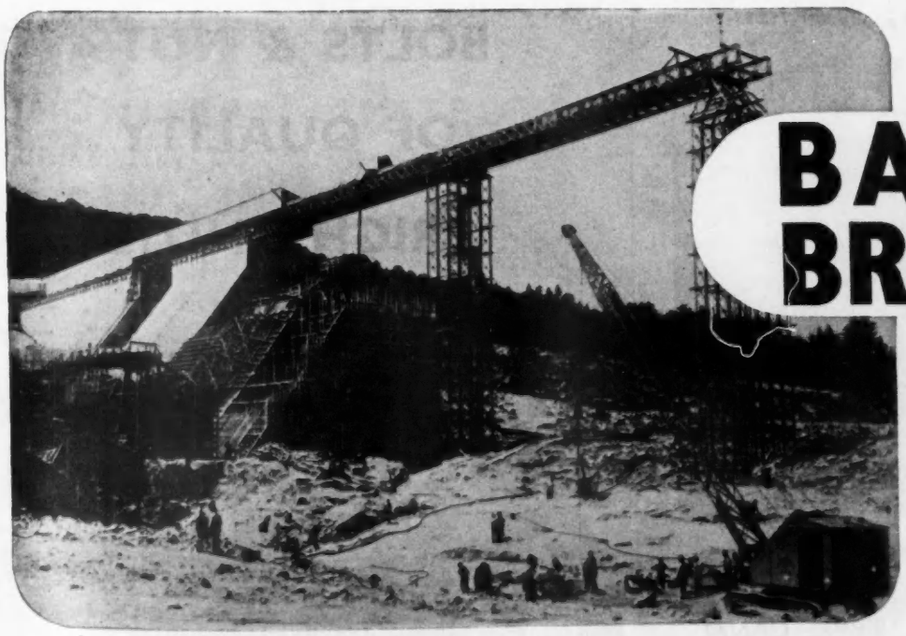

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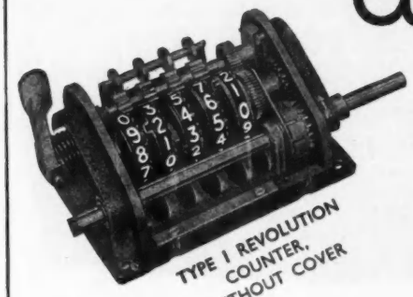

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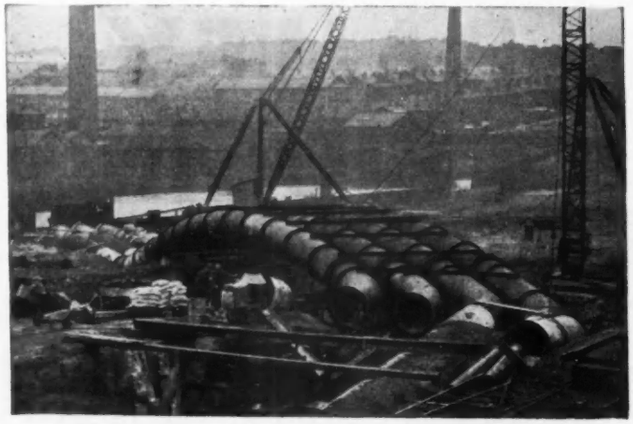

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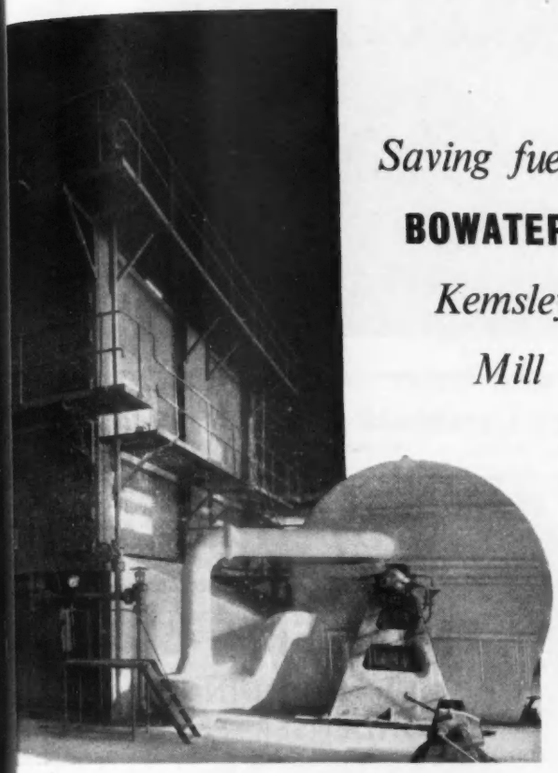

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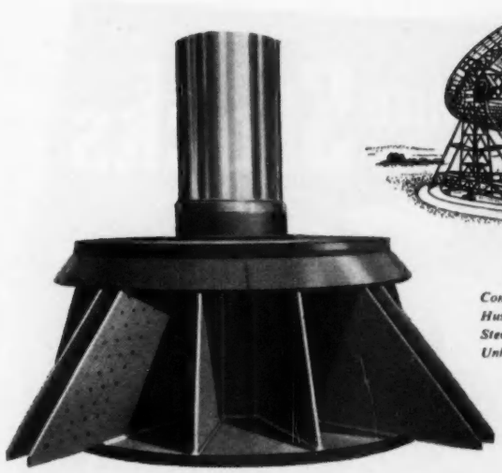

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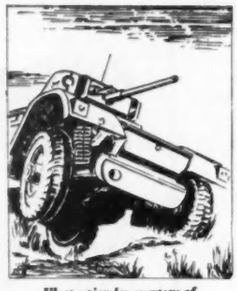

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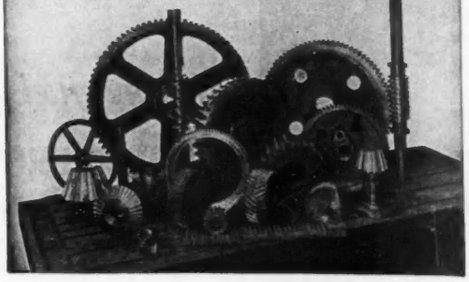

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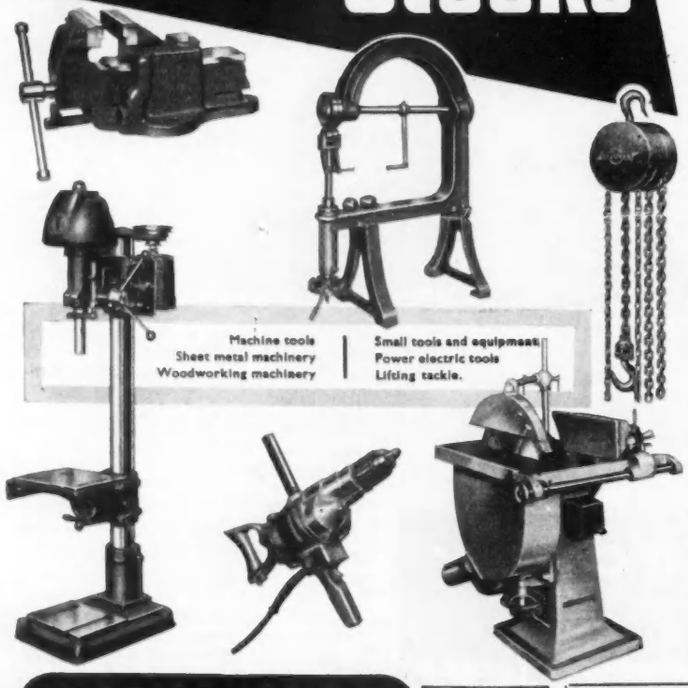

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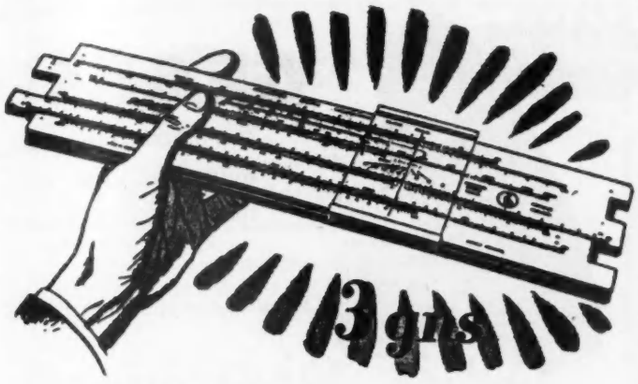

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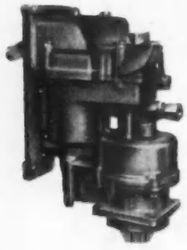

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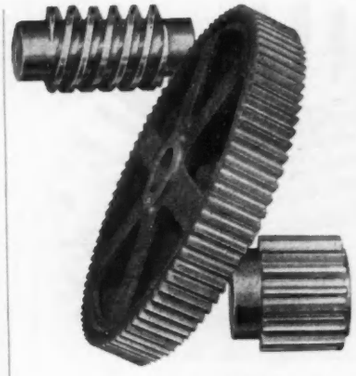

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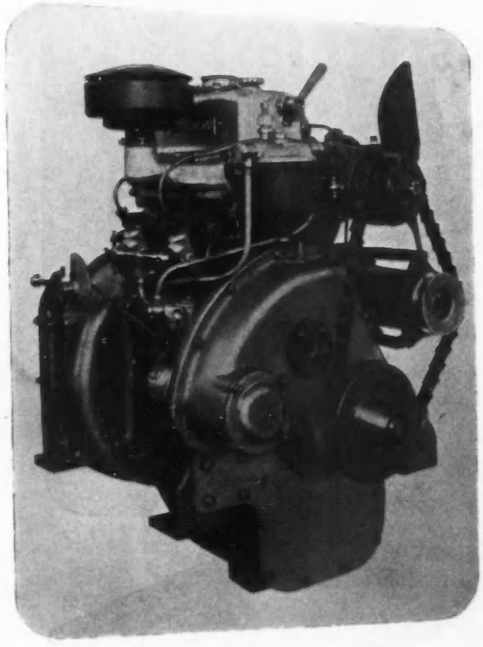

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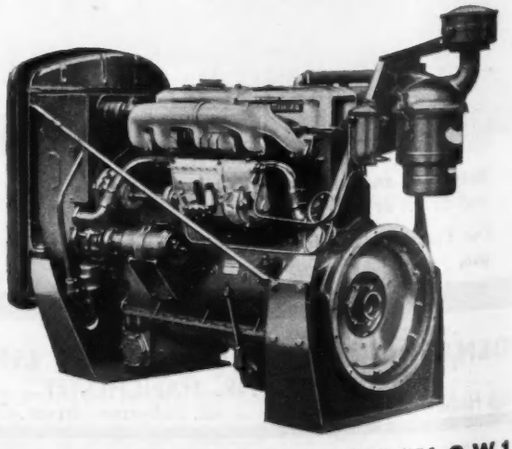

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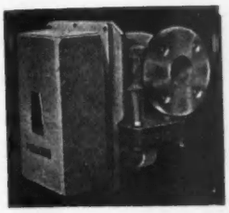

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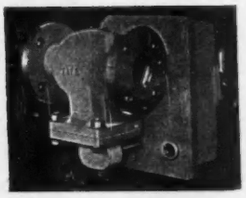

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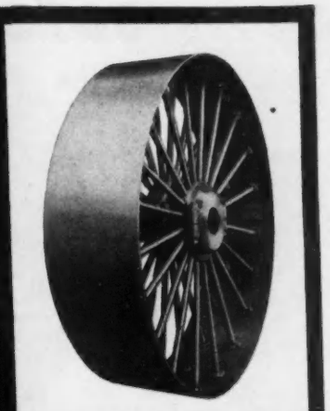

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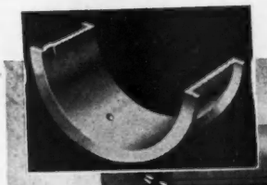

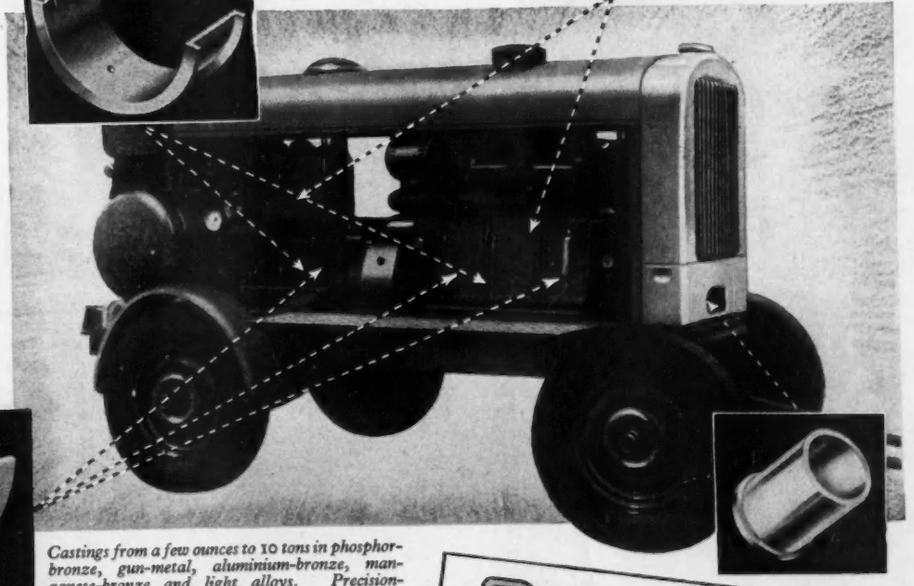

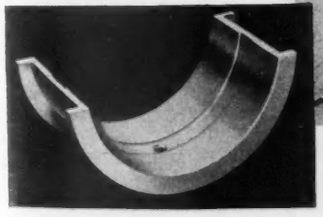

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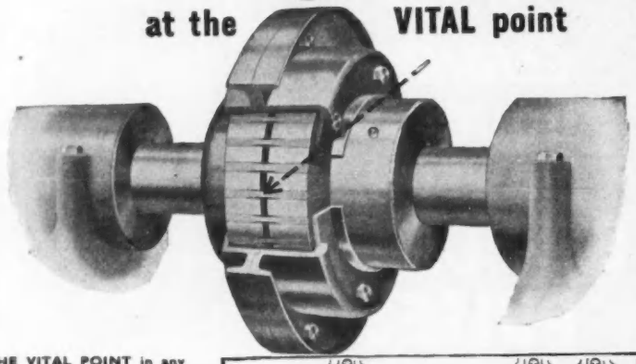

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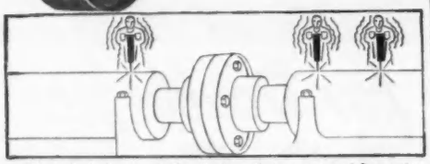
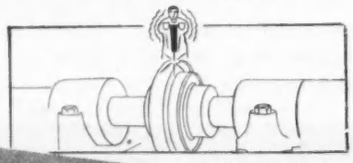


Unless checked, accumulative shocks and stresses passed from unit to unit will result in rapid deterioration of plant.



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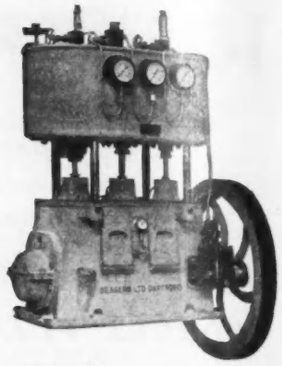

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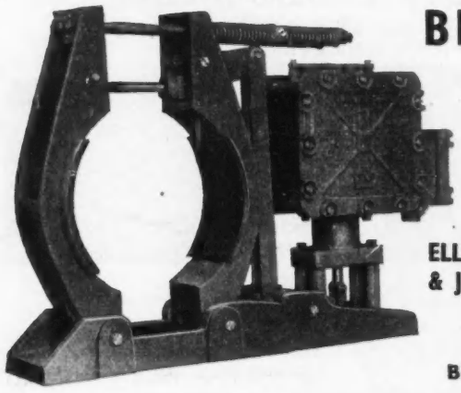

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Applicants are asked to send full details of age, training and experience to the PERSONNEL MANAGER. L 826

ASSISTANT WORKS ENGINEER required by industrial concern in West Midlands. Age 26-35. Engineering degree and industrial experience essential. Duties include supervision over maintenance and construction of wide range of plant and buildings. Salary according to qualifications and experience. Pension scheme. Housing Assistance if required.—BOX L 805, Offices of ENGINEERING.

A Firm of Heavy Vehicle Manufacturers in the South of England require a

MACHINE SHOP SUPERINTENDENT

capable of taking charge of more than 800 machines. This is a senior position of responsibility and will be remunerated accordingly. Pension Scheme in operation.—BOX L 803, Offices of ENGINEERING.

FERODO LIMITED, CHAPEL-EN-LE-FRITH Via Stockport, have vacancies for the following:—

1. **GENERAL ENGINEERING DRAUGHTSMEN,** age 25 to 40, having experience in machine design and works layouts. A knowledge of Works Buildings design desirable but not essential. Technical education at least to O.N.C. Ref. 2444/1.
2. **JIG AND TOOL DRAUGHTSMEN,** age 25 to 40. A knowledge of General Engineering and Machine Design advantageous, but not essential. Technical education at least to O.N.C. Ref. 2444/2.

Suitable applicants are offered excellent working conditions and canteen facilities. There is a contributory superannuation scheme.

You are invited to submit full details of experience, age, qualifications and salary required to the PERSONNEL MANAGER, quoting the appropriate reference number. L 712

THE G.E.C. STANMORE LABORATORIES require

ENGINEERS WITH H.N.C. OR DEGREE, with some knowledge of aircraft electrical work and preferably some experience of airborne equipment for planning the installation of radar equipment in aircraft. Applicants without the necessary academic qualifications but with considerable experience of this type of work will receive serious consideration.—Please apply, in writing, to the STAFF MANAGER, G.E.C. STANMORE LABORATORIES, THE GROVE, STANMORE, MIDDX., quoting ref. E/JT. L 485

DESIGN ENGINEER. A progressive light engineering company producing electrical/mechanical components for the motor industry require staff, 25/40 years, for development of production models. Applicants should hold H.N.C. or equivalent, with some experience in Laboratory Work and Design. Apply in writing stating age, experience, and salary required to the PERSONNEL OFFICER, SIMMS MOTOR UNITS, LTD., OAK LANE, N.2. L 596

Classified Advertisements continued on Page 124

ESTIMATOR AND RATEFIXER

required for Toolroom in a well-established engineering organisation engaged on large quantity production in the Automobile Industry. Applicants must have had a sound engineering training and be fully conversant with the production and maintenance of jigs, tools, fixtures and special equipment, and in particular with the application of effective bonus schemes in regard to Toolroom production. Excellent conditions; Good remuneration; Pension Scheme.

Housing accommodation available in the New Town for successful applicant.

Write in the first instance to
LABOUR MANAGER,
ALFORD & ALDER (ENGINEERS) LTD.,
MAYLANDS AVENUE, HEMEL HEMPSTEAD. HERTS. L 828

ELECTRICAL ENGINEERS who have completed their Military Service, and have some practical knowledge of design of any type of rotating electrical machinery, who would like to obtain experience in the design and manufacture of large high-speed Turbo-Generators, are invited to apply for a position which provides scope for development and the opportunity to take part in interesting work.

Apply, giving particulars of age and experience, to :—
CHIEF ENGINEER,
TURBO-GENERATOR ENGINEERING DEPARTMENT,
METROPOLITAN-VICKERS ELECTRICAL CO., LTD.,
TRAFFORD PARK, MANCHESTER, 17. L 771

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable but not essential, applicants with general mechanical engineering experience will be favourably considered. The posts offer excellent opportunities with generous salaries commensurate with experience and ability. Offices situated in the N.W.1 London area. Five-day week and superannuation scheme. Applications, which will be treated in confidence, should give previous experience and qualifications, and be addressed to the CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. G 664

SENIOR DEVELOPMENT ENGINEERS for the design and development of mechanical and electrical components for Power Cables of all voltages; for Telecommunication Cables and Overhead Current systems for electric traction. Candidates should be qualified to degree standard and preferably have had some production experience.

FULLY EXPERIENCED MACHINE SHOP VIEW ROOM INSPECTORS required. Pension Scheme. Special transport facilities from Bournemouth, Poole, Salisbury, Ringwood, Christchurch and Dorchester.—Apply in writing to PERSONNEL MANAGER, FLIGHT REFUELLING LIMITED, TARRANT RUSHTON AIRFIELD, NR. BLANDFORD, DORSET. L 831

SENIOR DESIGN ENGINEERS for the design of new and original accessories for Low, Medium and High Voltage Power Cables. Higher National Certificate or equivalent qualification is desirable, and production experience essential.

Applications quoting reference P/39/56 should be submitted to the STAFF OFFICER, B.I.C.C. LTD., PRESCOT, LANCS. L 832

MAINTENANCE ENGINEER. A vacancy exists for a Maintenance Engineer on the permanent staff at a large sugar refinery. Experience in charge of mechanical engineering maintenance is essential and education must be to at least H.N.C. standard in Mechanical Engineering. Applicants who must be medically fit and aged not more than 45, should apply in writing, giving details of their career to the CHIEF ENGINEER, TATE & LYLE LIMITED, LOVE LANE SUGAR REFINERY, LIVERPOOL, 3. L 867

MUNICIPAL MUTUAL INSURANCE LIMITED has vacancies for
ENGINEER SURVEYORS at Birmingham, Manchester, Nottingham and London. Posts are pensionable and permanent to satisfactory candidates who should have served an apprenticeship and have sound practical and theoretical knowledge. Technical qualifications: First Class Ministry of Transport Certificate. Salary: £675-£1000 per annum.—Apply in own handwriting marking the envelope "Application Engineer Surveyor" and "Private and Confidential," to the CHIEF ENGINEER, 22, OLD QUEEN STREET, WESTMINSTER, S.W.1. L 810

ESTIMATOR (SENIOR) required by Steel Pipe Manufacturing Firm in S.W. England. Progressive position. Pension scheme. Salary, £800-£1000 p.a. —BOX L 797, Offices of ENGINEERING.

DEVELOPMENT ENGINEERS AND PHYSICISTS

are required for work in the new and rapidly expanding laboratories of Louis Newmark Ltd. at New Addington, Surrey. The work includes the design and development of instruments and equipment for the aircraft and allied industries, and some working experience of small electromagnetic instruments is desirable. Good salary based on age and experience. Pension Scheme. Apply in writing, giving full particulars to: PERSONNEL OFFICER, LOUIS NEWMARK LTD., PREFECT WORKS, PURLEY WAY, CROYDON. L 836

SENIOR ENGINEER/AGENT required for Persian Gulf area. Applicants should have at least 8 years' site experience, preferably with Contractors and will be required to take charge of Branch Organisation responsible to Directors. Initial contract period 2/3 years with possibility of extension. Salary will be about £200 per month plus living expenses. Bachelor preferred but not essential.—Write with full particulars to BOX L 863, Offices of ENGINEERING.

£200 PER ANNUM or more is offered for a
DEPUTY DIRECTOR OF RESEARCH
for BRITISH WELDING RESEARCH ASSOCIATION. Applicant must have a good Honours degree in metallurgy, and be prepared to live in the Cambridge area. Apply:—DIRECTOR OF RESEARCH, B.W.R.A., 29, PARK CRESCENT, LONDON, W.1. L 769

A Leading Oil Company requires a
MARINE ENGINEER, not over 35 years of age, with University degree or equivalent qualification and experience, preferably sea going, of large marine diesel engines, for post in technical branch dealing with operational problems and development of fuels and lubricants for marine diesel engines and lubricants for all types of marine machinery. Headquarters will be in London but candidates must be prepared to travel abroad for short periods. Knowledge of languages will be an advantage. Non-contributory Pension Scheme.—Write, giving full details, quoting H.A.2, to BOX 8964, c/o 191, GRESHAM HOUSE, E.C.2. L 860

PRODUCTION ENGINEER required for Senior Appointment with Leading Motor Car Manufacturers, to be responsible for controlling Production Planning, Machine Tool Specification, Jig, Tool and Gauge Design, and Plant Layout.

Applicants must prove a successful record in a similar capacity, and should not be over 45 years of age. Only those with experience of Modern Machine Techniques, Assembly and Layout, and of managing a large staff need apply.

The position is superannuated, carries substantial remuneration, and presents first-class opportunities for advancement.

Applications will be treated in strict confidence, should contain full particulars, and be addressed to BOX EG.296, c/o 191, GRESHAM HOUSE, E.C.2. L 859

CORROSION ENGINEER

required by Major Oil Company for service in Venezuela, Graduate or equivalent qualification. The work is mainly in connection with Cathodic Protection of which the candidate should have had several years' practical experience, but a background of more general knowledge of corrosion is also desirable. Candidates must be able and willing to take responsibility and to assist in the general planning and administration of co-ordinated corrosion control programme, covering all aspects of oil production, storage and transport.

This position, for which candidates of approximately 25/35 years of age will be considered, is pensionable age 53. Tours of two and three years' duration with one month's paid leave in U.K. for each year of tour overseas. First class passage provided for family including children up to 18 years of age. Successful candidate will be located in modern City where climatic conditions are tropical but in no way unhealthy. Company schooling to 12 years of age provided together with adequate medical care. Knowledge of Spanish advantageous but not essential although working knowledge at end of first tour would be expected. Commencing salary according to qualifications and experience. Please write, giving full details, age, qualifications, experience, marital status, to BOX Z8.450, DEACON'S ADVERTISING, 36, LEADENHALL STREET, LONDON, E.C.3. L 845

DEVELOPMENT ENGINEER; a vacancy exists for a Development Engineer at a large Sugar Refinery. The duties involve investigation of technical problems both practical and theoretical, production of technical specifications for new plant, commissioning and testing plant, under the general control of the Development Engineer. Candidates must have a good general education and University Degree in Mechanical (or Chemical) Engineering, and be under 35 years of age.—Applicants should write giving details of their career to the CHIEF ENGINEER, TATE & LYLE LIMITED, LOVE LANE SUGAR REFINERY, LIVERPOOL, 3. L 868

NELSON ENGINEERING LABORATORIES,
STAFFORD.

The English Electric Co. Ltd. require

TWO GRADUATE ENGINEERS

for work involving the use of Analogue Computing Techniques in the Study of electric Power System performance.

These posts involve the Study of the performance of interconnected rotating machines and the operational behaviour of protective Systems, and will also provide opportunities for both practical and theoretical development work on analogue computers.

There are good prospects for advancement in an expanding development organisation, and candidates should write with full details to DEPT. C.P.S., 336/7, STRAND, W.C.2, quoting Ref. 1218A. L 842

DISTRIBUTION ENGINEER.

Applications are invited from qualified Engineers for the post of Distribution Engineer with Baghdad Electricity Services. Applicants, aged 30 to 40 years, should have experience in all branches of an Electricity Distribution System, including 33-kV, 11-kV, L.T., underground cables and overhead lines, sub-stations, maintenance and erection. Experience in generating plants is not required but will be an advantage.

Three-year contract in first instance at a net salary of approximately Iraqi Dinars 200 to 225 (£200 to £225) per month according to qualifications, including high cost of living allowance. Provident fund exists. Free house with heavy furniture provided. Three months' leave on full salary after completion of 24 months' service in Iraq with first class passages including wife and family. BOX L 694, Offices of ENGINEERING.

METHODS ENGINEER. First-class Engineer required for Methods work in medium-sized general engineering factory in Lancashire, engaged in the manufacture of high-grade machinery. It is very essential that applicants should be at present engaged on Methods engineering and have wide experience on the shop floor. Successful candidate will participate in a generous superannuation scheme and will receive an annual bonus payment.—Write, with full details of age, experience, salary required, etc., to BOX L 792, Offices of ENGINEERING.

THE GENERAL ELECTRIC CO., LTD., has a vacancy in the editorial section of its Publicity Organisation for a
WRITER CAPABLE OF PREPARING INFORMATION for the national, technical and trade press, conducting active press relations, and producing literature. This is a post which offers scope to a technical journalist and/or University graduate with an interest in the wide field of activities covered by the Company, but principally in electronics, radio and television.—Applications should include full details of education, age, qualifications, experience, and salary required, together with specimens of written work, and should be addressed to the STAFF MANAGER, THE GENERAL ELECTRIC CO., LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2. L 809

AUTOMATION

This is a new, interesting and expanding field involving the design and development of Light and Medium Weight Automatic Special-purpose Machines which embrace the processing and assembly of Electronic Apparatus. **ENGINEERS WITH EXPERIENCE** of this class of work are invited to apply for vacancies which exist in the self-contained Laboratories of a large Engineering Company situated in the London Area. The appointments are permanent and progressive with a salary range up to £1200 p.a.—Please reply, giving full details of qualifications experience to BOX L 862, Offices of ENGINEERING.

ENGINEER MANAGER.

Applications are invited from fully qualified Engineers for the post of Engineer Manager with Baghdad Electricity Services. Applicants, aged 35 to 45 years, should have experience in all branches of an Electricity Supply Undertaking, including administration, distribution and generation by oil-fired boilers and turbo-alternators. Experience in the erection of plant will be an advantage. Three-year contract in first instance at a net salary of approximately Iraqi Dinars 270 (£270) per month including high cost of living allowance. Provident Fund exists. Free house with heavy furniture provided. Three months' leave on full salary after completion of 24 months' service in Iraq with first class passages including wife and family.—BOX L 693, Offices of ENGINEERING.

SENIOR ENGINEER, a vacancy exists for a Senior Engineer on the Permanent staff at a large sugar refinery. Experience in charge of mechanical engineering maintenance is essential and it would be an advantage to have experience of operation and maintenance of steam and power generating plant. Applicants, who must be medically fit and aged not more than 40, and who should be either A.M.I.Mech.E. or equivalent standard, should apply in writing giving details of their career to the CHIEF ENGINEER, TATE & LYLE, LIMITED, LOVE LANE SUGAR REFINERY, LIVERPOOL, 3. L 869

GRADUATE ENGINEER (MECHANICAL OR ELECTRICAL) with an aptitude for tuition required for duties which include lectures and demonstrations on the techniques and characteristics of special cables to the Company's and Customers' selected personnel. Previous experience is not essential; training can be given to the selected candidate if necessary who would have the opportunity to transfer to other duties later.—Applications to be submitted to the STAFF OFFICER, BRITISH INSULATED CALLENDER'S CABLES LTD., PRESCOT, LANCS., quoting reference P/23/56. L 843

BRITISH PETROLEUM COMPANY LIMITED has a vacancy for an
ELECTRONIC ENGINEER for work in the Instrument Group at its Research Station at Sunbury-on-Thames. Applications are invited from men with a University Degree in Physics or Electrical Engineering or equivalent. Some experience in the design and development of electronic instruments preferable. Work will include development of instruments for the control and testing of internal-combustion engines, for process control, and for chemical and physical measurements. Age under 35. National Service obligations must have been fulfilled. Good Pension Scheme. Salary according to age, qualifications and experience.—Write, giving full details, quoting H.3303 (*a*) to BOX 8952, c/o 191, GRESHAM HOUSE, E.C.2. L 858

KELLOGG
INTERNATIONAL CORPORATION

Design and Construction Engineers of world-wide repute in the petroleum and chemical industries invites applications from junior and senior graduate chemical and/or mechanical engineers as

PROCESS PIPING ENGINEERS.

The work consists of the preparation of piping flow diagrams both for process and utility systems. Engineers in these positions will work intimately with the process design of refinery and chemical plants and handle problems of instrumentation, pumping, gas compression, heat exchange and other unit operations. A formal training programme is arranged for new employees.

The Corporation offers comprehensive employee benefits which include:

CONTRIBUTORY PENSION SCHEME.
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FULL INSURANCE COVER FOR DUTY JOURNEYS.
HOUSE PURCHASE ASSISTANCE SCHEME.
GENEROUS OVERTIME PAYMENTS.
LUNCHEON VOUCHERS.
ETC.

THOSE WHO KNOW OUR NAME KNOW WE PAY WELL.

Write now to
PERSONNEL MANAGER,
Dept. 66/H,
KELLOG INTERNATIONAL CORPORATION
7-8, Chandos Street,
London, W.1.

Holiday arrangements will be honoured. Interviews can be arranged to suit applicants by prior appointment by telephoning MUSeum 4010.

L 693

Leading manufacturers of container closures in the Midlands have a number of vacancies for ambitious **DESIGN DRAUGHTSMEN** preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation. Write in confidence with details of experience, positions held, salary required, to P.A. METAL CLOSURES LIMITED, BROMFORD LANE, WEST BROMWICH. G 627

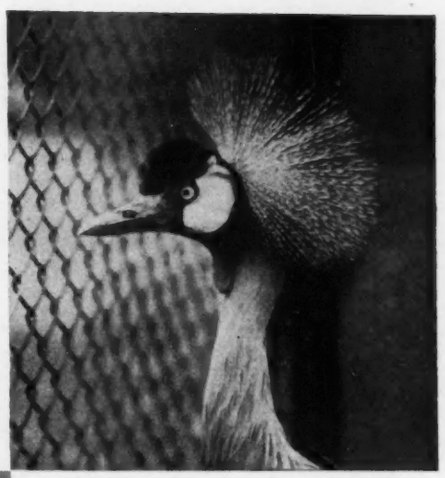
Well-known Midland aero engine company requires **MECHANICAL ENGINEERING DESIGNERS AND DRAUGHTSMEN** to join teams on various aspects of engine construction. Initial salary, £650-£1000 per annum. Owing to expansion in new drawing offices with excellent working conditions departments will offer good prospects to men with initiative. Sickness benefits for families and pension fund. Full details quoting Reference AD/2, to BOX G 632, Offices of ENGINEERING.

INSTALLATION ENGINEER. Manufacturers of diesel and electrical components for the motor industry require an experienced Installation Engineer, 25-40 yrs., for work in conjunction with the Design Dept. Education to H.N.C. preferred, although experience in similar work would be considered in the absence of academic qualifications. Apply in writing giving full details including salary required to—PERSONNEL OFFICER, SIMMS MOTOR UNITS, LTD., OAK LANE, E. FINCHLEY, N.2. L 597

PERFORATED METALS
for all purposes
MILD STEEL, STAINLESS STEEL, COPPER, BRONZE, BRASS, ETC.
Specialists in Rotary Screens, Elevators, Storage Bins, Conveyors, Washers for Sand and Gravel
J. & F. Pool LTD.
EST. 1848
HAYLE CORNWALL

206

MEK-ELEK Engineering Ltd.,
17, Western Road, Mitcham, Surrey
MITcham 3072. Cables: Mekelek, London.



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Eclipse

the best hack saw blade

"Eclipse" hack saw blades, tool bits and other engineers tools are made by: James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UH6

ATOMIC ENERGY

H. M. HOBSON LTD.,

require the services of a first grade

ELECTRO-MECHANICAL DESIGNER

to take charge of the Design Office in their rapidly expanding

NUCLEAR ENGINEERING DIVISION

dealing mainly with control and ancillary equipment for Nuclear Reactors.

Preferably applicants should have an engineering degree or equivalent combined with a broad background of engineering design.

This is an Executive Staff appointment carrying an attractive salary. A pension scheme is in operation.

Write giving full particulars to

H. M. HOBSON LTD.,
FORDHOUSES,
WOLVERHAMPTON,
STAFFS. L 778

ASSISTANT WORKS ENGINEER required by RICHARDSONS WESTGARTH (HARTLEPOOL) LIMITED. Applicants should have a good working knowledge of Machine Tools and will be responsible for the repair and maintenance of all such equipment in the Hartlepool Works. With a view to later extension of responsibility to include maintenance of buildings, electrical equipment and all services throughout the Factory, experience of such work would be an advantage.

Applications should be sent to the Group's Head Office, addressed to:—
THE MANAGING DIRECTOR,
RICHARDSONS WESTGARTH & CO., LTD.
(P.O. BOX No. 2),
WALLSEND, NORTHUMBERLAND.
and marked "Appointment; Strictly Confidential." They will not be disclosed without consent.

L 813

F. PERKINS LIMITED require a **QUALIFIED ENGINEER,** for extended tours in Europe. Experience of Installation Problems of diesel engines (or I.C. engines) as power units for Vehicle, Agricultural, Industrial and Marine applications required. Engine sales experience and fluent knowledge of technical German are essential qualifications, other languages an asset. This is a senior appointment with good prospects.—Apply with full particulars to F. PERKINS LIMITED, EXPORT SALES DEPARTMENT, PETERSCOURT, PETERBOROUGH. L 801

MANAGEMENT AND INDUSTRIAL CONSULTANTS
engaged in all types of Production, Organisation, Administrative and Costing functions are open to **ENGAGE ADDITIONAL STAFF.** Applicants must possess highest technical and professional qualifications in Engineering or Accountancy and should have practical managerial experience. Age not over 40. Remuneration on a high scale with superannuation and expense allowances.—Full details of qualifications and experience to BOX L 737, Offices of ENGINEERING.

A WELL KNOWN FIRM making Mechanical Presses and Special Machines, including "Automation" Equipment, has **VACANCIES IN ITS DESIGN OFFICE.** Interesting and creative work with opportunities for independent constructive thinking. Young men in course of training would be considered.—Apply stating experience, etc., to BOX L 752, Offices of ENGINEERING.

WANTED.

DESIGN ASSISTANT required immediately for company manufacturing prestressed concrete. Knowledge of prestressed concrete design not essential. Write giving details of qualifications, experience and salary required, to:—
CHARLTON CONCRETE CO., LTD.,
7a, PULTENEY STREET,
BATH,
SOMERSET. L 837

Classified Advertisements continued on Page **126**

MECHANICAL ENGINEER.

A young man about 30 years of age is required to work as an industrial engineering supervisor (in Outer London Area); must have served an indentured apprenticeship and had some years practical experience; a knowledge of Automatic Packing and Weighing Machinery and Electronics would be an advantage.

Technical Training up to B.Sc. (Engineering) or Higher National Certificate standard.

Commencing Salary £950 to £1200 according to qualifications and experience; pension scheme and sports club facilities.

Write giving full details of education, practical and technical training to BOX L 660, Offices of ENGINEERING.

ASSISTANT CIVIL ENGINEERS required for immediate posts in Scotland. Positions are long term and carry opportunities where desired for work in London and later abroad. Assurance and staff pensions. Categories required:—

(*a*) Graduates qualifying in 1956, who desire opportunity to complete requirements for Associate Membership of the Institution of Civil Engineers.

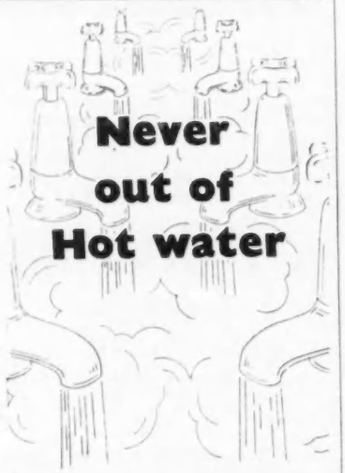
(*b*) Associate Membership of the Institution of Civil Engineers or similar standard for either design or site supervision.

BOX G 644, Offices of ENGINEERING.

STRUCTURAL ENGINEER with wide experience of the design and detailing of all types of steel structures and with administrative experience required to act as deputy to the Chief Engineer by large firm of London Consultants. The firm is expanding and the vacancy offers excellent opportunities for the right type of man.—Write in confidence giving details of previous experience and salary required to BOX No. 355, GLOVERS ADVERTISING LTD., 351, OXFORD STREET, LONDON, W.1. G 635

ASSISTANT CIVIL ENGINEERS, both Senior and Junior, wanted by Consulting Engineers for their London Office. Applicants must be good draughtsmen with design experience in one or more of the following; marine works, roads, railways, structural concrete, structural steel.

Five-day week, superannuation scheme, luncheon and sports clubs. Apply by letter with full particulars of age, qualifications and experience to BOX No. 40, c/o CHARLES BARKER & SONS, LTD., 31, BUDGE ROW, LONDON, E.C.4. L 853



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Money Saving! *Take advantage of the Special rates offered by The Electricity Boards for "off peak" loads.*

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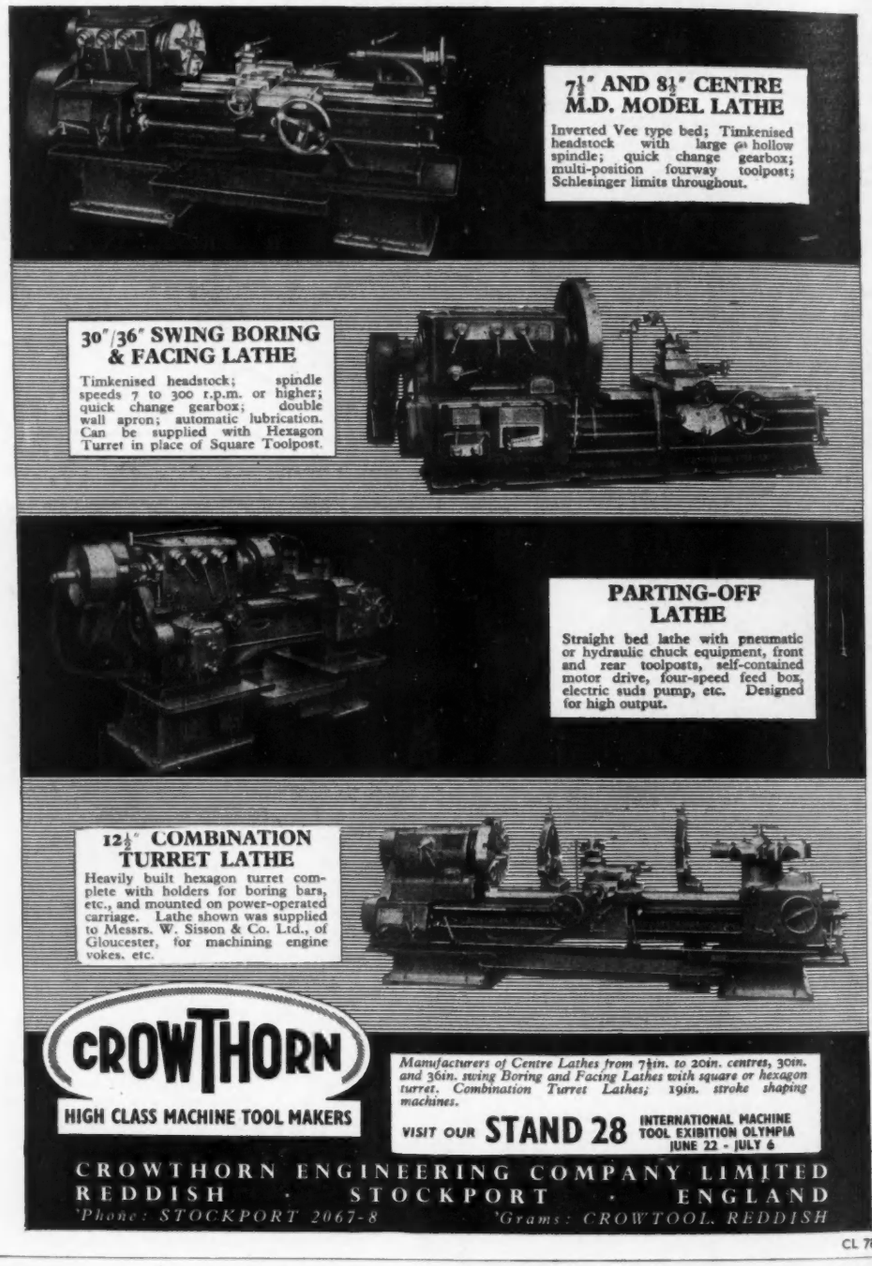
7½" AND 8½" CENTRE M.D. MODEL LATHE
Inverted Vee type bed; Timkenised headstock with large ø hollow spindle; quick change gearbox; multi-position fourway toolpost; Schlesinger limits throughout.
30"/36" SWING BORING & FACING LATHE
Timkenised headstock; spindle speeds 7 to 300 r.p.m. or higher; quick change gearbox; double wall apron; automatic lubrication. Can be supplied with Hexagon Turret in place of Square Toolpost.
PARTING-OFF LATHE
Straight bed lathe with pneumatic or hydraulic chuck equipment, front and rear toolposts, self-contained motor drive, four-speed feed box, electric suds pump, etc. Designed for high output.
12½" COMBINATION TURRET LATHE
Heavily built hexagon turret complete with holders for boring bars, etc., and mounted on power-operated carriage. Lathe shown was supplied to Messrs. W. Sisson & Co. Ltd., of Gloucester, for machining engine yokes, etc.
CROWTHORN
HIGH CLASS MACHINE TOOL MAKERS
Manufacturers of Centre Lathes from 7½in. to 20in. centres, 30in. and 36in. swing Boring and Facing Lathes with square or hexagon turret. Combination Turret Lathes; 19in. stroke shaping machines.
VISIT OUR STAND 28 INTERNATIONAL MACHINE TOOL EXIBITION OLYMPIA JUNE 22 - JULY 6
CROWTHORN ENGINEERING COMPANY LIMITED
REDDISH · STOCKPORT · ENGLAND
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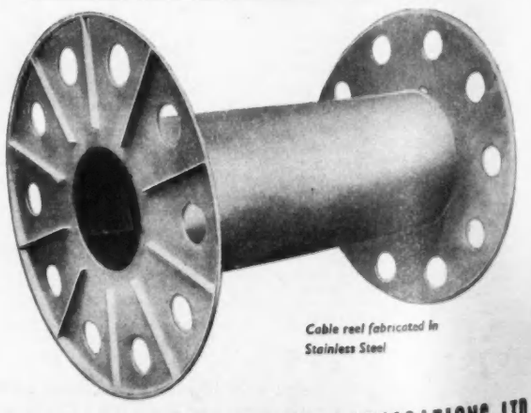
FABRICATION ENGINEERS TO ALL INDUSTRIES

We are equipped to undertake expeditiously accurate fabrication in all metals and would especially welcome enquiries for Bedplates, Baseplates, Gear Cases, Engine Frames, Tanks and Vessels, Heat Exchangers, Condensers, etc.



Cable reel fabricated in Stainless Steel

NORTHFIELD INDUSTRIAL FABRICATIONS LTD
Park Works, Ossett Yorks. Phone: Ossett 587 Grams: "Plateweld Ossett"

ALLEY

ALLEY & MACLELLAN (POLMADIE) LTD.
COMPRESSOR SPECIALISTS
would like to hear from a keen and enthusiastic young man aged 25/30, who would be interested in continued development of new designs and research investigation.
Qualifications should include University Honours, Engineering degree and preferably some experience in centrifugal or rotary compressor design.

Address applications to
Technical Manager, Alley & Maclellan (Polmadie) Ltd: Glasgow, S.2 L830

APPLICATIONS ARE INVITED for the following appointments at the CLAYDON, SUFFOLK, Works of THE BRITISH STEEL PILING CO., LTD.

STRUCTURAL DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent). Candidates should be capable of accepting responsibility for complete projects.

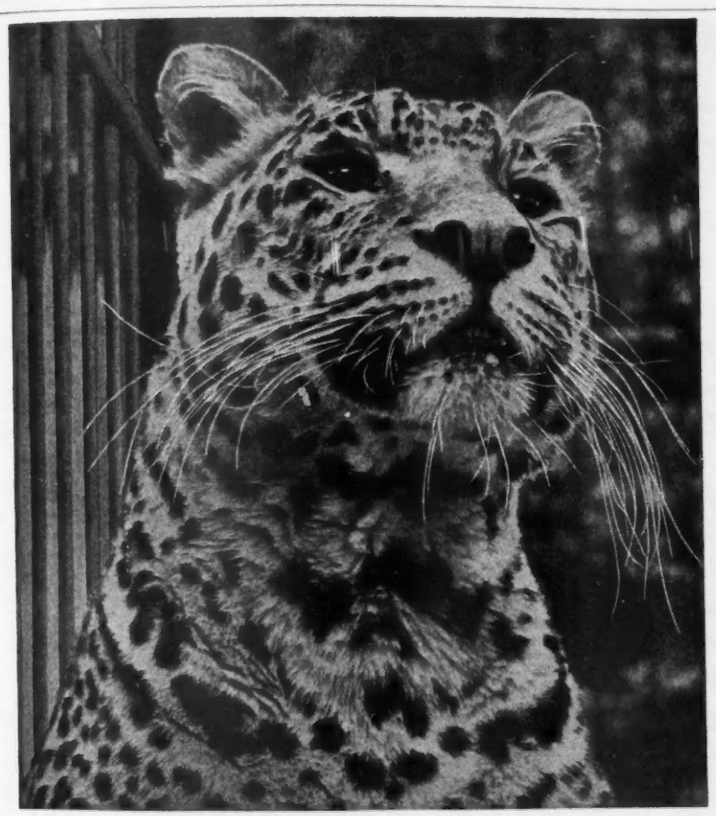
MECHANICAL DESIGNER DRAUGHTSMAN (Minimum qualifications H.N.C. or equivalent, but consideration also given to candidates who have not yet completed their studies).

Experience should preferably (but not essentially) include equipment such as cranes, hoisting machinery (steam, diesel, electric) mechanical handling equipment, contractors' plant.

THESE ARE PROGRESSIVE PERMANENT POSITIONS IN AN EXPANDING ORGANISATION. The Company operates a contributory pension scheme and good Canteen facilities exist. Present Holiday arrangements respected. Salary in accordance with age, qualifications and experience. The Works are situated 15 minutes' bus ride from the centre of Ipswich. Applications to Works Manager at the above address. L 602

HEAT TRANSFER AND FLUID FLOW. Research and Development Engineer required by an old-established Engineering Company in the Glasgow area. Applicants, aged 25-30, should have a University Honours Degree in Engineering and some research experience. The work would involve the theoretical design and practical testing of new types of heat exchanger. A good salary would be paid to an applicant with the necessary qualifications. Apply giving age and full particulars to BOX G 583, Offices of ENGINEERING.

BRITISH PETROLEUM COMPANY, LIMITED, has immediate vacancies for **CHEMISTS, PHYSICISTS, CHEMICAL ENGINEERS AND MECHANICAL ENGINEERS** for work in their United Kingdom Refineries and at their Research Station at Sunbury-on-Thames. Applications are invited from men with University degrees or equivalent qualifications and who have fulfilled National Service obligations. Previous Industrial experience desirable but not essential. Age preferably not above 33. Salaries within the range £650-£1300 according to qualifications and experience. Excellent working conditions. Non-contributory Pension Scheme.—Write, giving full details quoting H.3297 to BOX 8580, c/o 191, GRESHAM HOUSE, E.C.2. G 565



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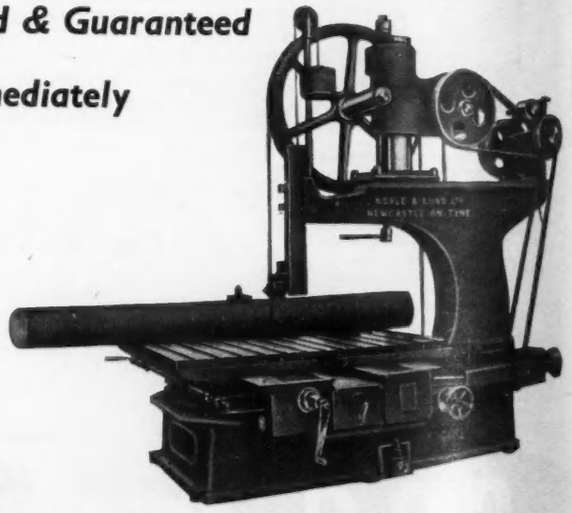

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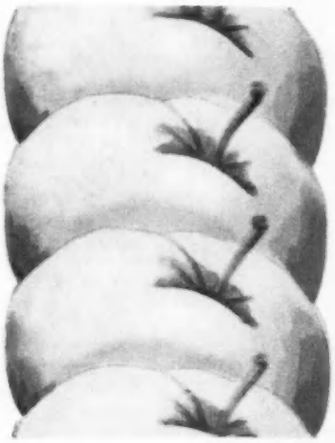

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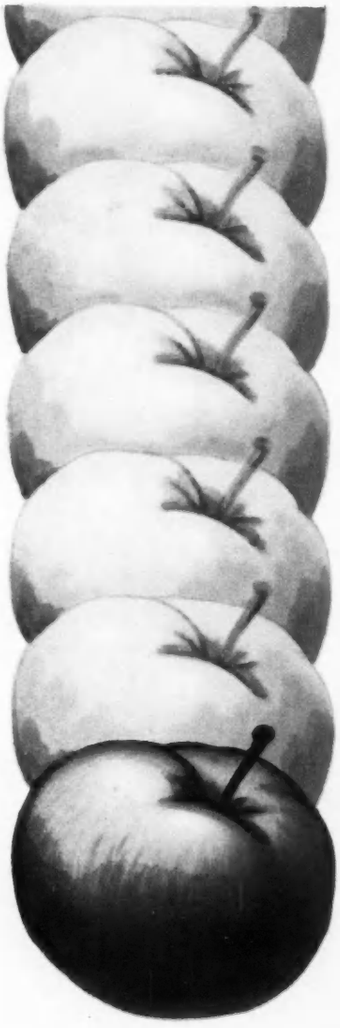

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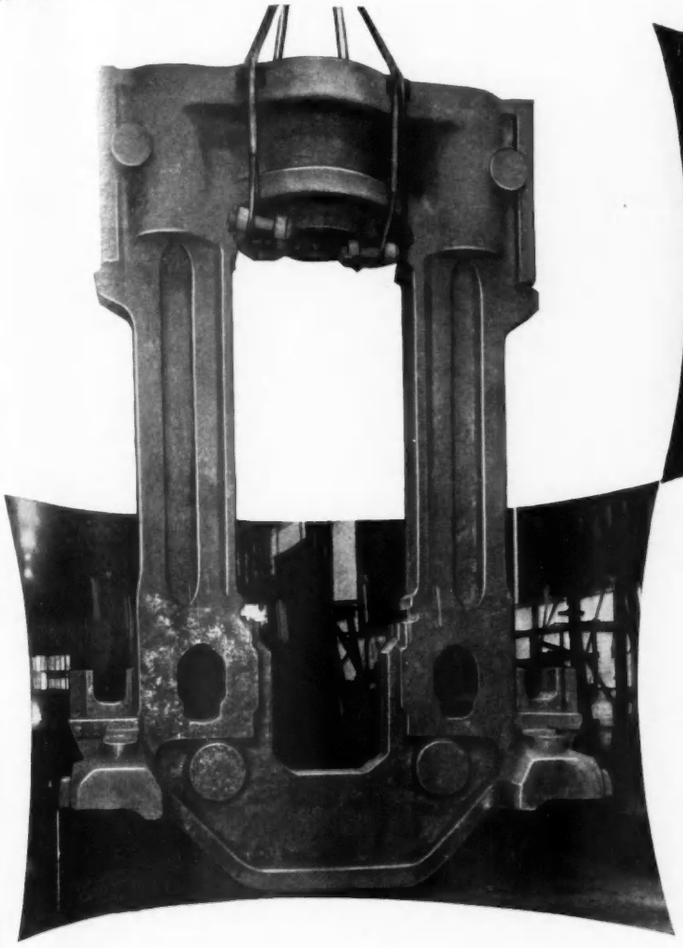

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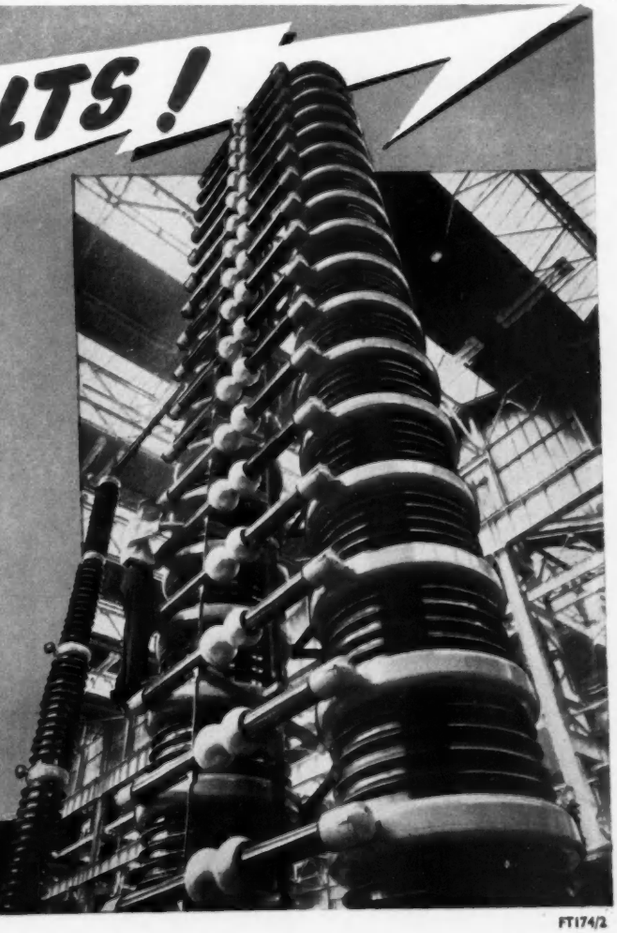

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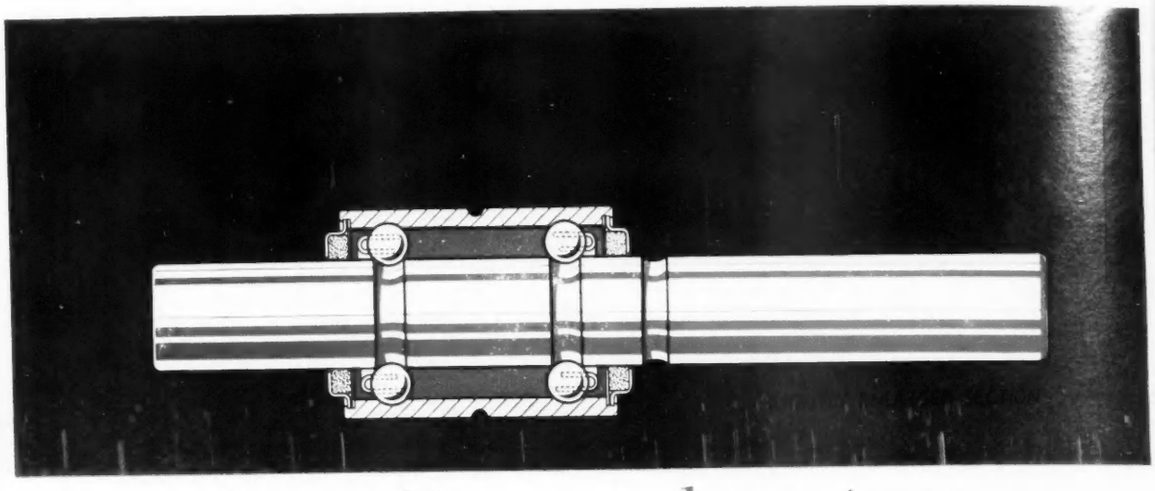

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